

# SP-G2: EFFECTS OF PROJECT OPERATIONS ON GEOMORPHIC PROCESSES DOWNSTREAM OF OROVILLE DAM

- Task 1.1 - Resources and References
- Task 1.2 - Physiographic Setting and Mesohabitat
- **Task 2 - Spawning Riffle Characteristics**
- Task 3 - Channel Cross-Sections and Photography
- Task 4 - Monitor Cross-Section and Gravel Locations
- Task 5 - Dam Effects on Hydraulics and Geomorphology
- Task 6 - Channel Meanders and Bank Erosion
- Task 7 - Hydraulic and Sediment Predictive Modeling
- Task 8 - Summary and Conclusions

## Questions about post-Oroville Dam spawning riffles...

- What is the extent of spawning gravels at the twenty main riffles between Oroville and Honcut Creek?
- Does the size of the gravels change significantly in this reach?
- Has the size changed over time?
- Are the gravels “armored”?
- What is the quality of the spawning gravels?
- In general, what are the permeabilities, temperatures, DO's and velocities at these riffles?



# OBJECTIVES

- MAP THE AERIAL EXTENT OF SPAWNING GRAVEL DEPOSITS
  - DIMENSIONS
- CHARACTERIZE SPAWNING GRAVEL RIFFLES
  - GRAVEL SAMPLING – MEASURE SIZE OF GRAVELS
  - GRAVEL QUALITY – COMPARE SIZES MEASURED WITH OPTIMAL RANGES FOR SPAWNING
  - ALSO MEASURE PERMEABILITY,
  - TEMPERATURE AND DISSOLVED OXYGEN, AND VELOCITY OF WATER

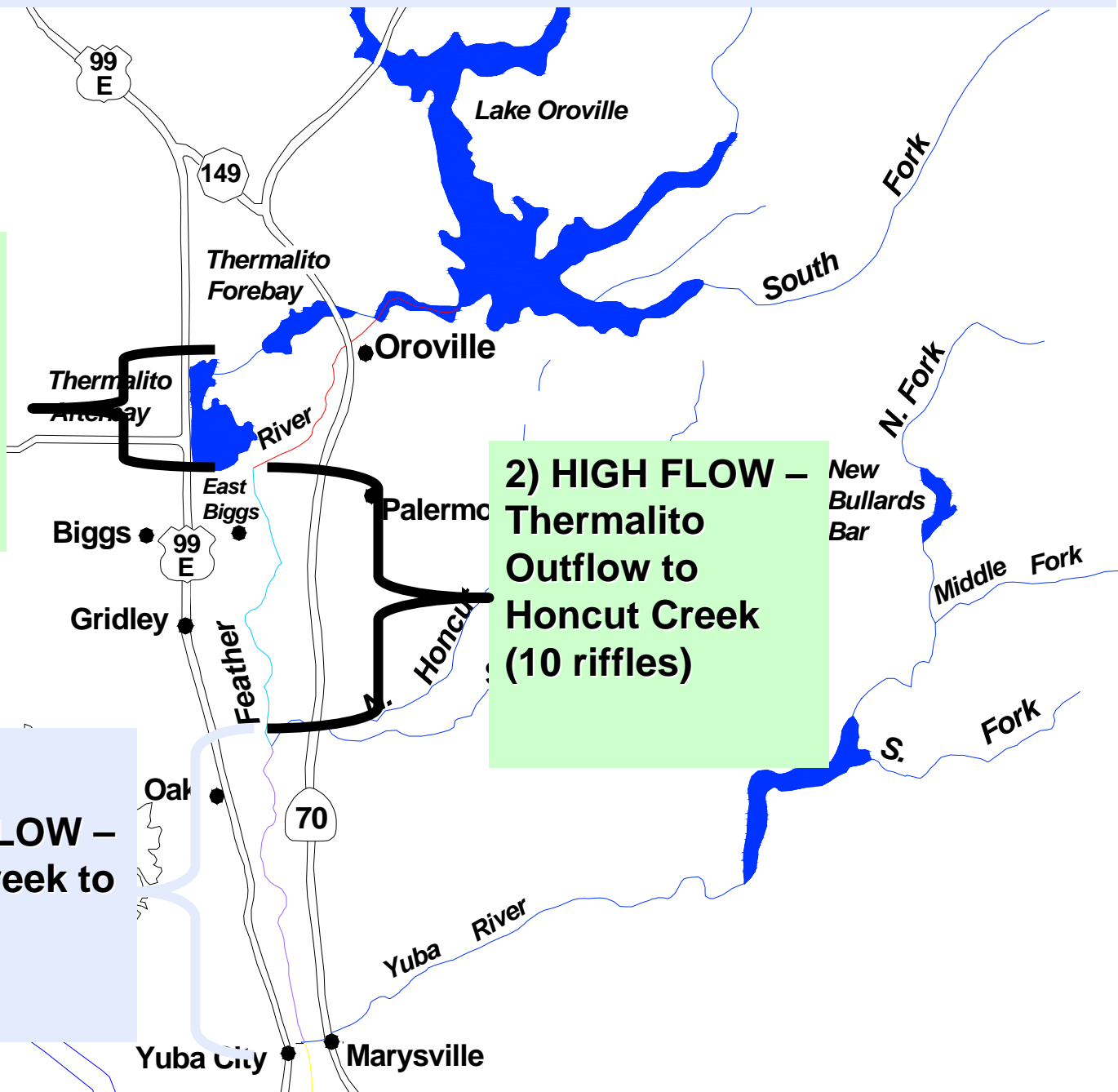


# SCOPE OF STUDY PLAN G2 --- TASK 2

**1) LOW FLOW**  
– Fish  
Diversion  
Dam to  
Thermalito  
Outflow  
(10 riffles)

**2) HIGH FLOW –**  
Thermalito  
Outflow to  
Honcut Creek  
(10 riffles)

**3) HIGH FLOW –**  
Honcut Creek to  
Yuba City

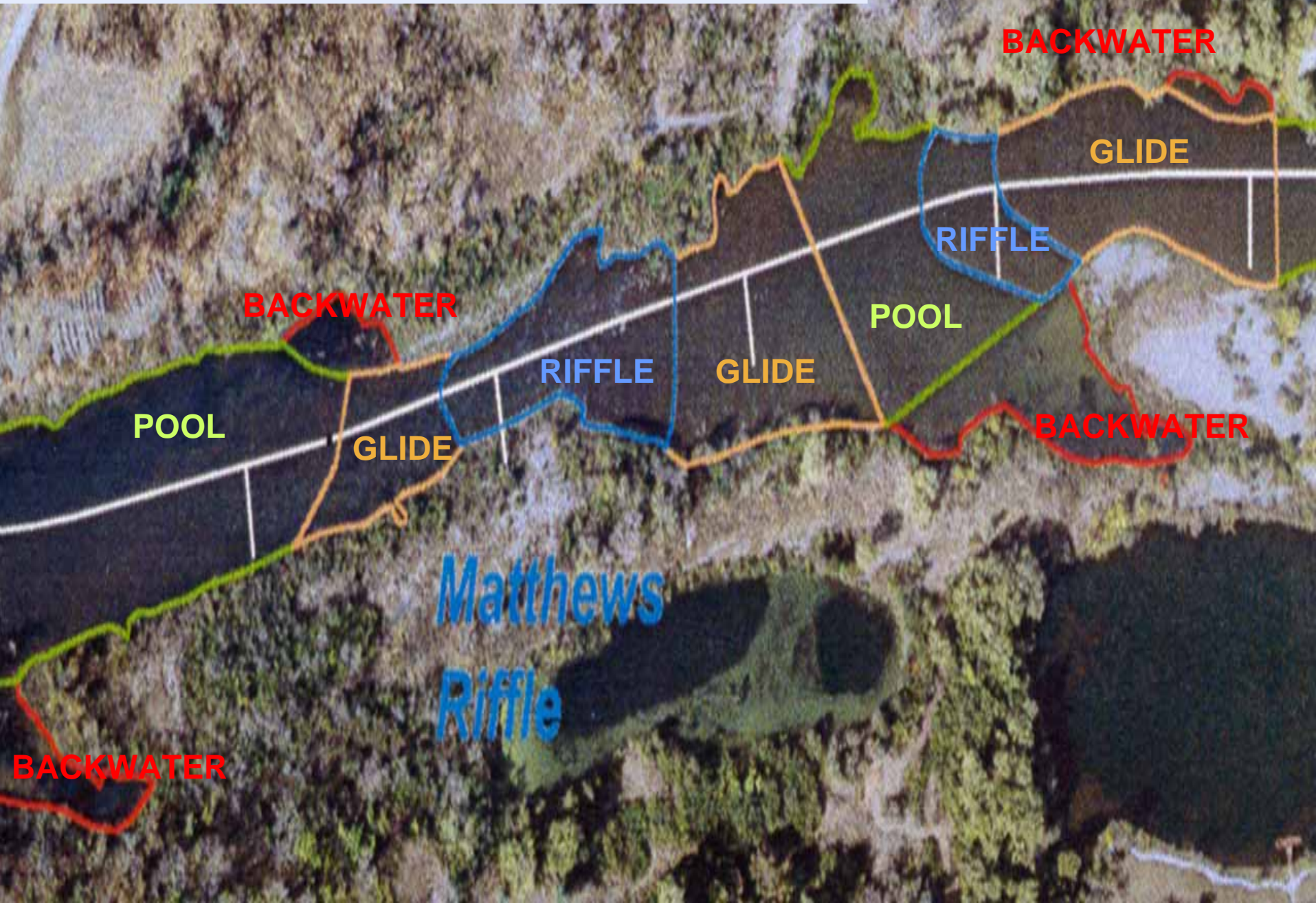


# SPAWNING RIFFLE CHARACTERIZATION

**“WHAT IS THE AREAL EXTENT OF SPAWNING  
GRAVEL DEPOSITS?”**

**(measure dimensions and calculate spawning area)**

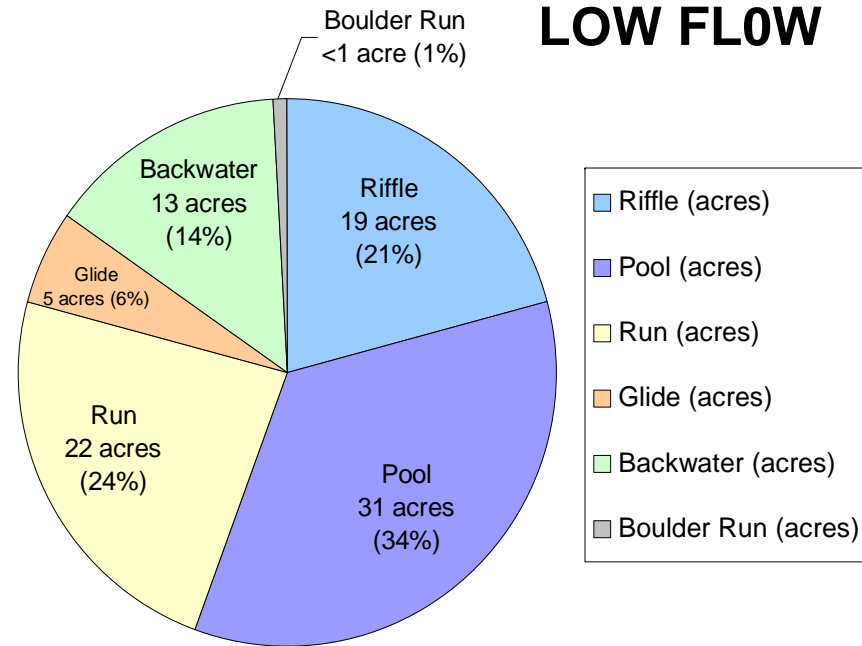
# TASK 1.2---Mesohabitat Mapping



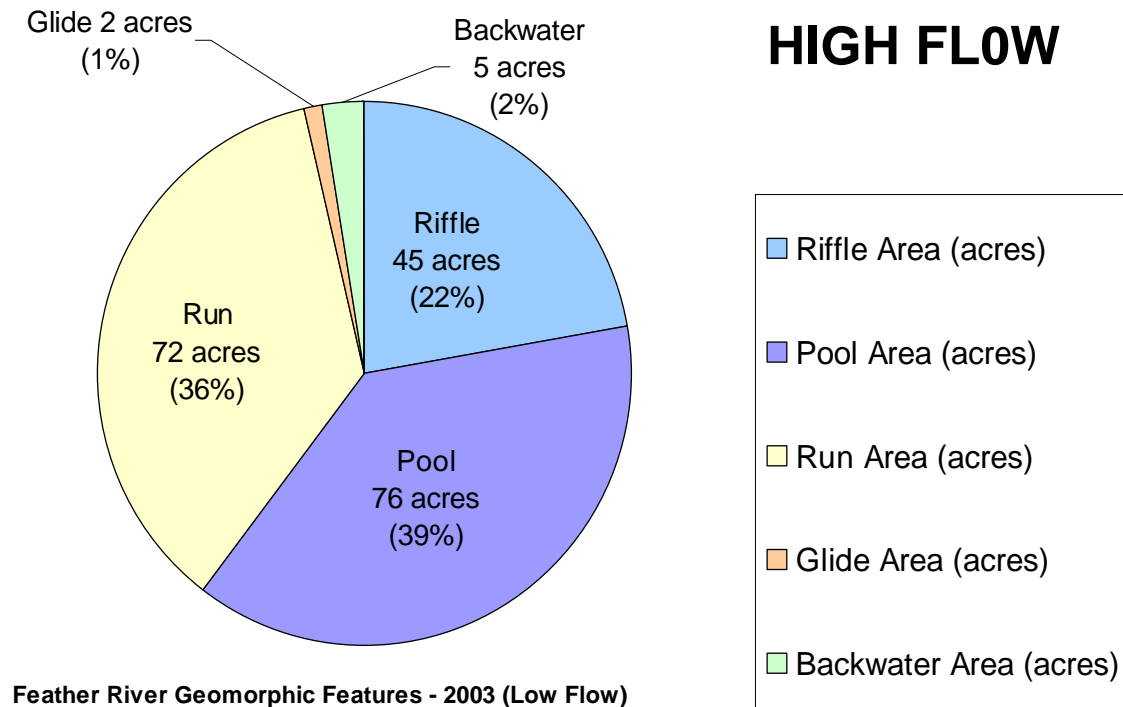
# Spawning Habitat Mapping at “Riffles”

- “Riffles” = 20 named reaches in Low and High Flow that are named and have historically significant salmon spawning
- relied on Task 1.2 mesohabitat mapping of
  - pools
  - riffles
  - runs
  - glides
  - backwaters
- riffles
  - low flow = 19 acres
  - high flow = 45 acres

## LOW FLOW



## HIGH FLOW



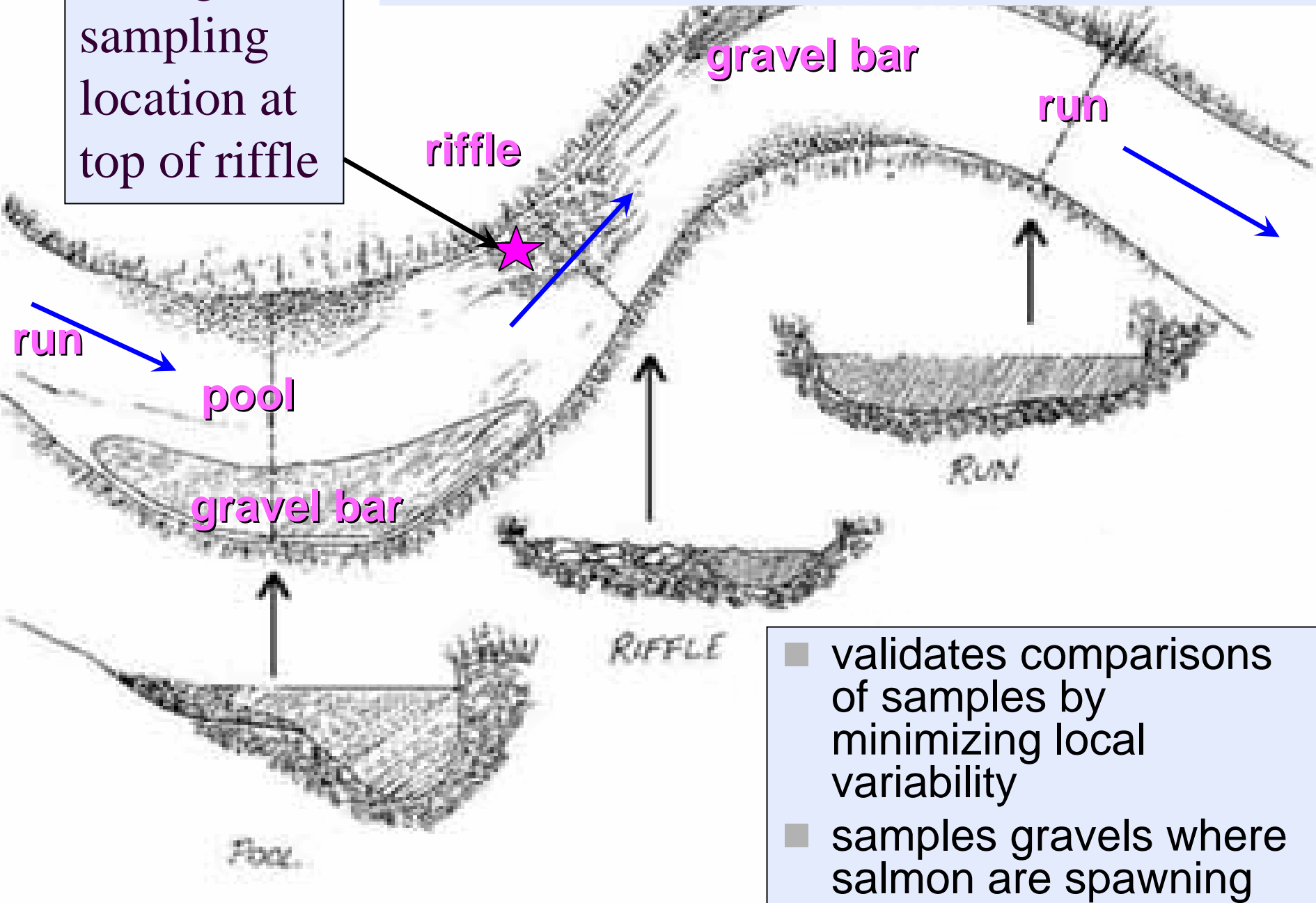
# SPAWNING RIFFLE CHARACTERIZATION

**“HAVE THE SIZES OF SPAWNING GRAVELS  
CHANGED SPATIALLY AND/OR OVER TIME?”**

**(analyze representative areas at the heads of  
riffles with bulk gravel sampling and surface  
sampling techniques)**

# SAMPLING PROTOCOLS (lateral)

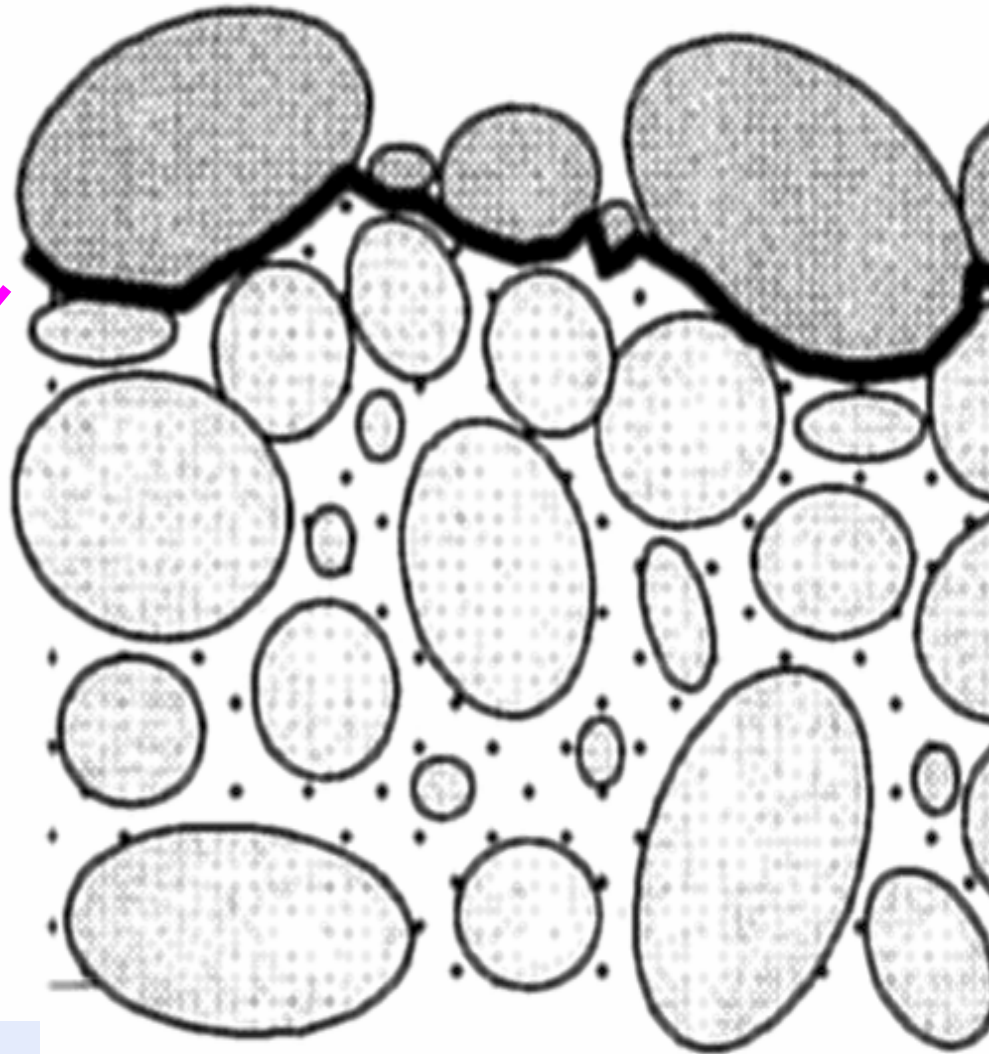
ideal gravel  
sampling  
location at  
top of riffle



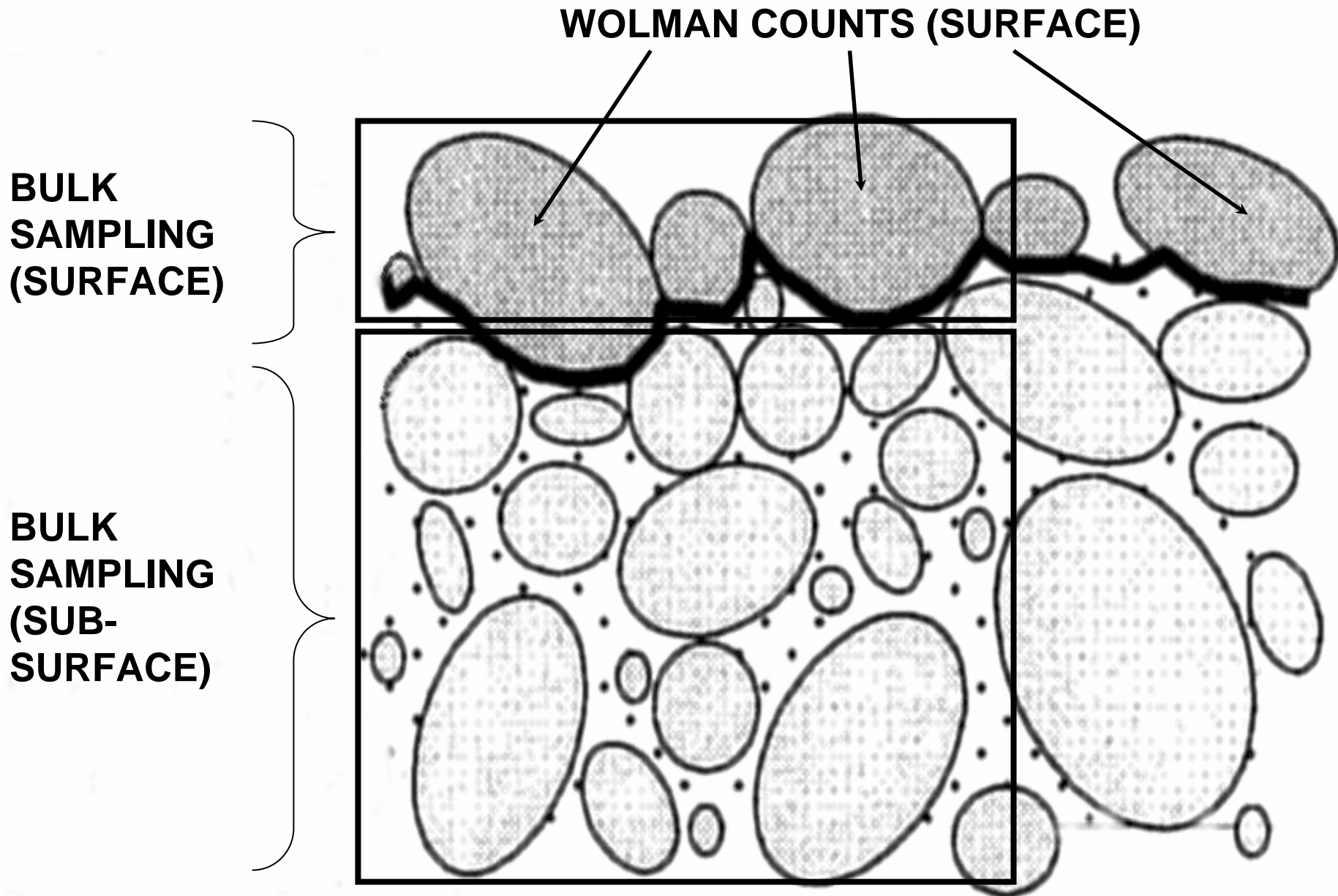


**SAMPLING PROTOCOLS  
(VERTICAL)**

**Surface sediment**



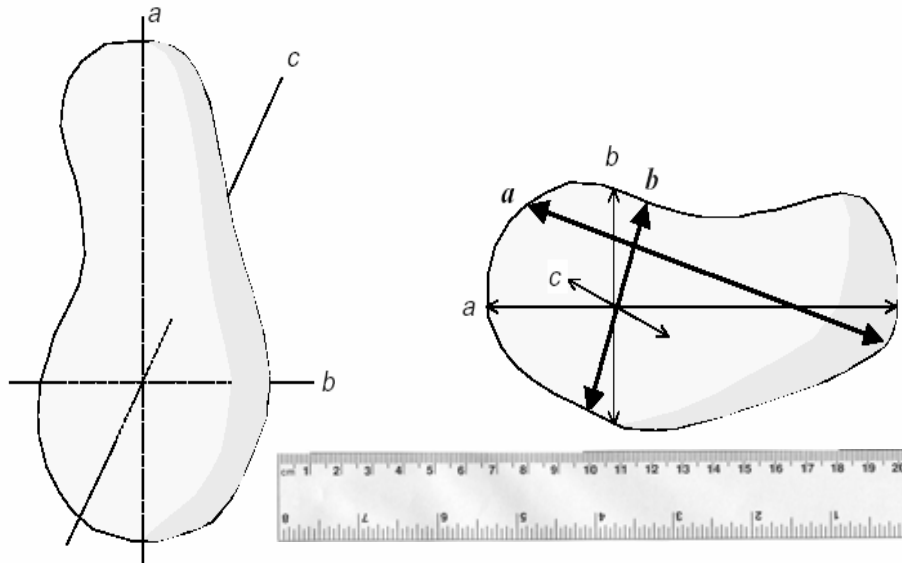
**Subsurface layer**



# GRAVEL SAMPLING METHODS

# WOLMAN SAMPLING

- surface sampling technique
- measures b-axis of pebble
- easy and quick
- 100 pebble minimum



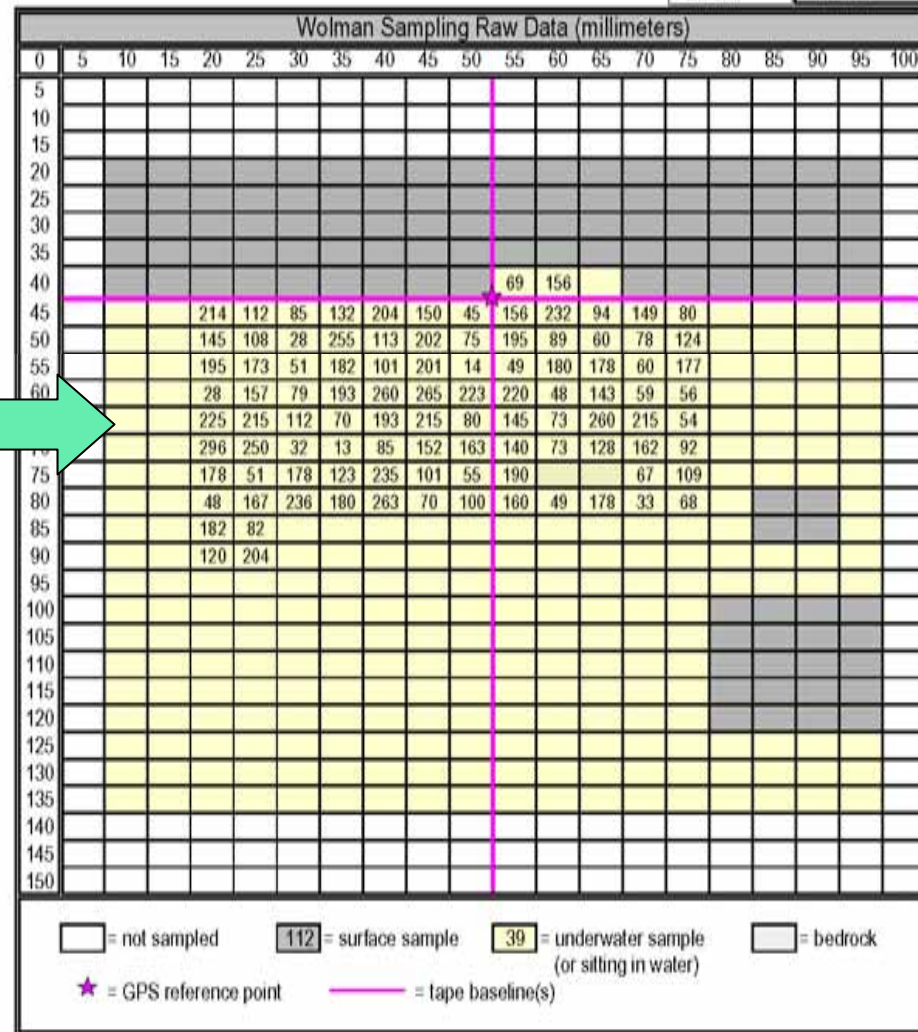
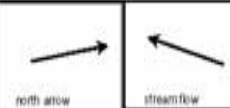
DATE: 10/18/02, 1:00 pm RM: 66.7 REACH: Low-flow SAMPLE CODE: WS - 102

PROJECT: FERC Feather River SP-G2 LOCATION: Hatchery Riffle

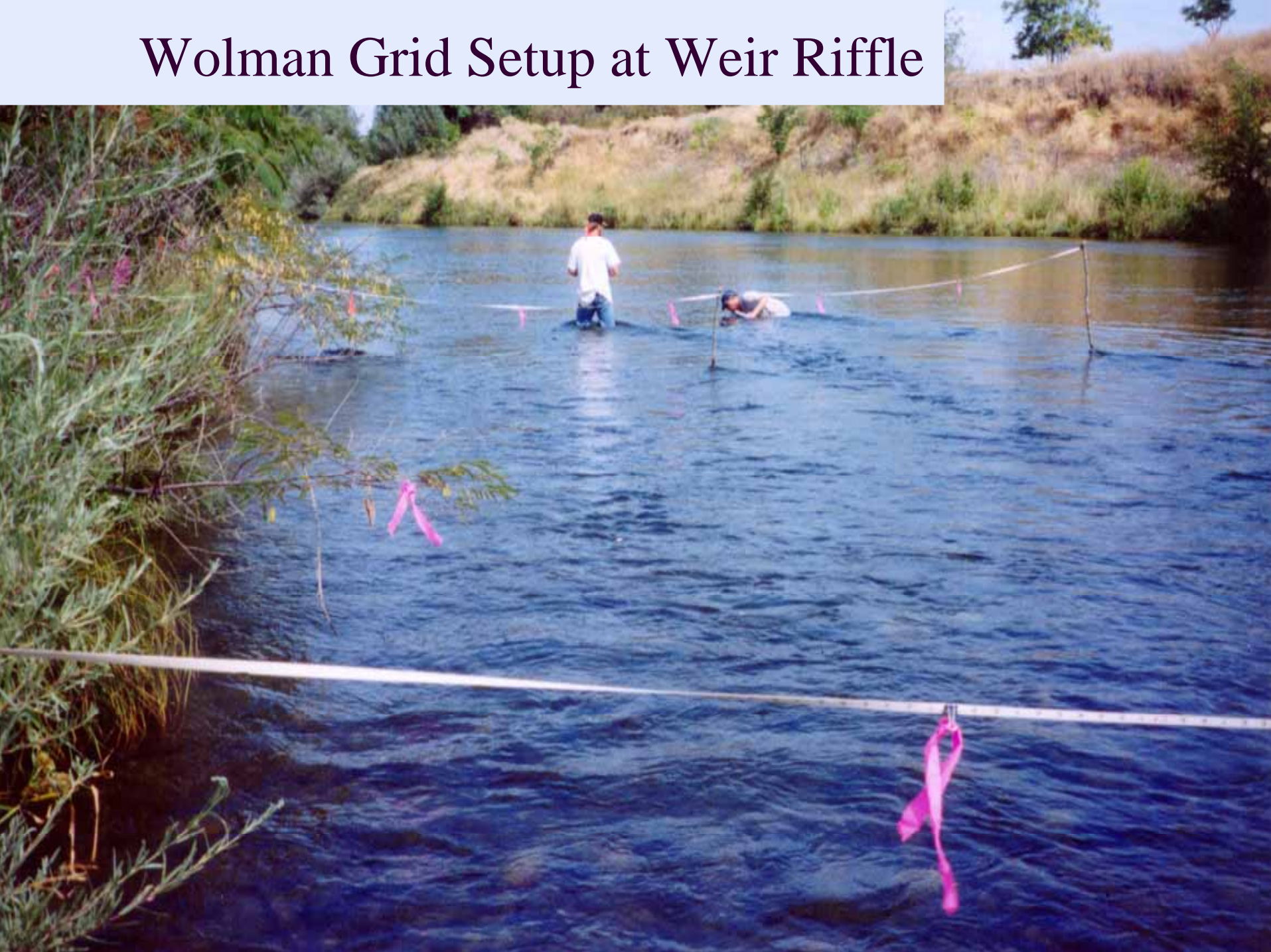
SAMPLING CREW: Dave Forwaller, Glen Gordon, Clint Andreason

COMMENTS: Adjacent to WS1-2 sampling location

GRID SIZE: HORIZ: 5.0 feet GPS Coords: Northing: 2314404.9  
(cell dimensions) VERT: 5.0 feet (Zone 2, NAD 83) Easting: 6687372.4

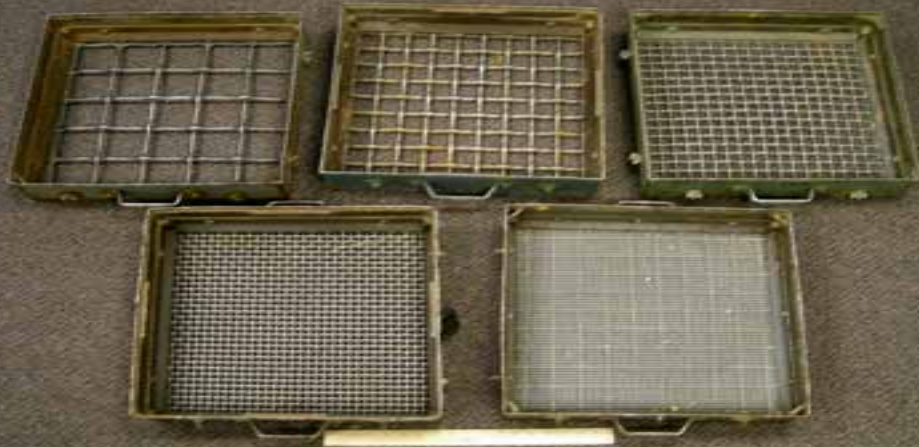


# Wolman Grid Setup at Weir Riffle



# BULK (volumetric) SAMPLING

- surface and sub-surface sediments
- sieving into different size ranges
- fairly labor and time intensive



## SPAWNING GRAVEL SIZE ANALYSIS

### FIELD ASSESSMENT

By: 6-6-96 Time: 11:00  
MS JS VVG (Sampling)  
me (Recording)

Project: FEATHER Sample #: B5  
 Site Location: OLD WEIR RIDDLE  
SURFACE PORTION

PLEASE DO SKETCH MAP OF SAMPLE SITE ON BACK

Sift # Sample#	SIFT 1 (lbs)	SIFT 2	SIFT 3	SIFT 4	SIFT 5	TOTAL WEIGHT	% OF SAMPLE	% PASSING	% RETAINED
MAX INT DIA	<u>5 1/2"</u>	<u>7.0 lbs</u>							
>6"	<u>0</u>					<u>0</u>			
3-6"	<u>17.5</u>	<u>7.0</u>	<u>9.0</u>	<u>14.0</u>	<u>32.0</u>	<u>79.5</u>			
1 1/2 - 3"	<u>53.0</u>	<u>22.0</u>	<u>34.0</u>	<u>42.5</u>	<u>—</u>	<u>151.5</u>			
3/4 - 1 1/2"	<u>41.5</u>	<u>36.0</u>				<u>77.5</u>			
3/8 - 3/4"	<u>32.0</u>					<u>32.0</u>			
#4 - 3/8"	<u>8.0</u>					<u>8.0</u>			
TOTALS									

(<#4)  
 TOTAL WET WEIGHT REMAINING (lbs): 29.0  
 TOTAL WET WEIGHT TO LABORATORY: 11.5

369.5

### LABORATORY ASSESSMENT

Date: 6/22/96 By: Mick Savarile

SIEVE SIZE	SIFT 1 (lbs) <u>grams</u>	SIFT 2	TOTAL WEIGHT	TOTAL MINUS TARE	SAMPLE FACTOR ADJUST.	% OF SAMPLE	% PASSING	% RETAINED
#4	<u>2.9</u>	<u>1.4</u>						
#8 - #4	<u>30.0</u>	<u>25.9</u>						
#16 - #8	<u>114.7</u>	<u>113.0</u>						
#30 - #16	<u>111.9</u>	<u>177.9</u>						
#50 - #30	<u>120.1</u>	<u>117.5</u>						
#100 - #50	<u>22.7</u>	<u>21.1</u>						
#200 - #100	<u>1.2</u>	<u>1.0</u>						
< #200	<u>0.8</u>	<u>0.5</u>						
TOTALS	<u>500.2</u>							

Oversize Weight:

Tare Value:

Lab Sample Minus Oversize Weight:

Lab Sample Total Weight:

% Weight Loss Upon Drying:

Wet Weight Total Adjusted to Dry Weight:

Sample Multiplication Factor:

Total Sample Weight (lbs):

COMMENTS:

Dry Weight = 11 lbs

# BULK SAMPLING AT AUDITORIUM RIFFLE, 2003



# BULK SAMPLING AT ALECK RIFFLE, 2003



# BULK SAMPLE SIEVING AND WEIGHING

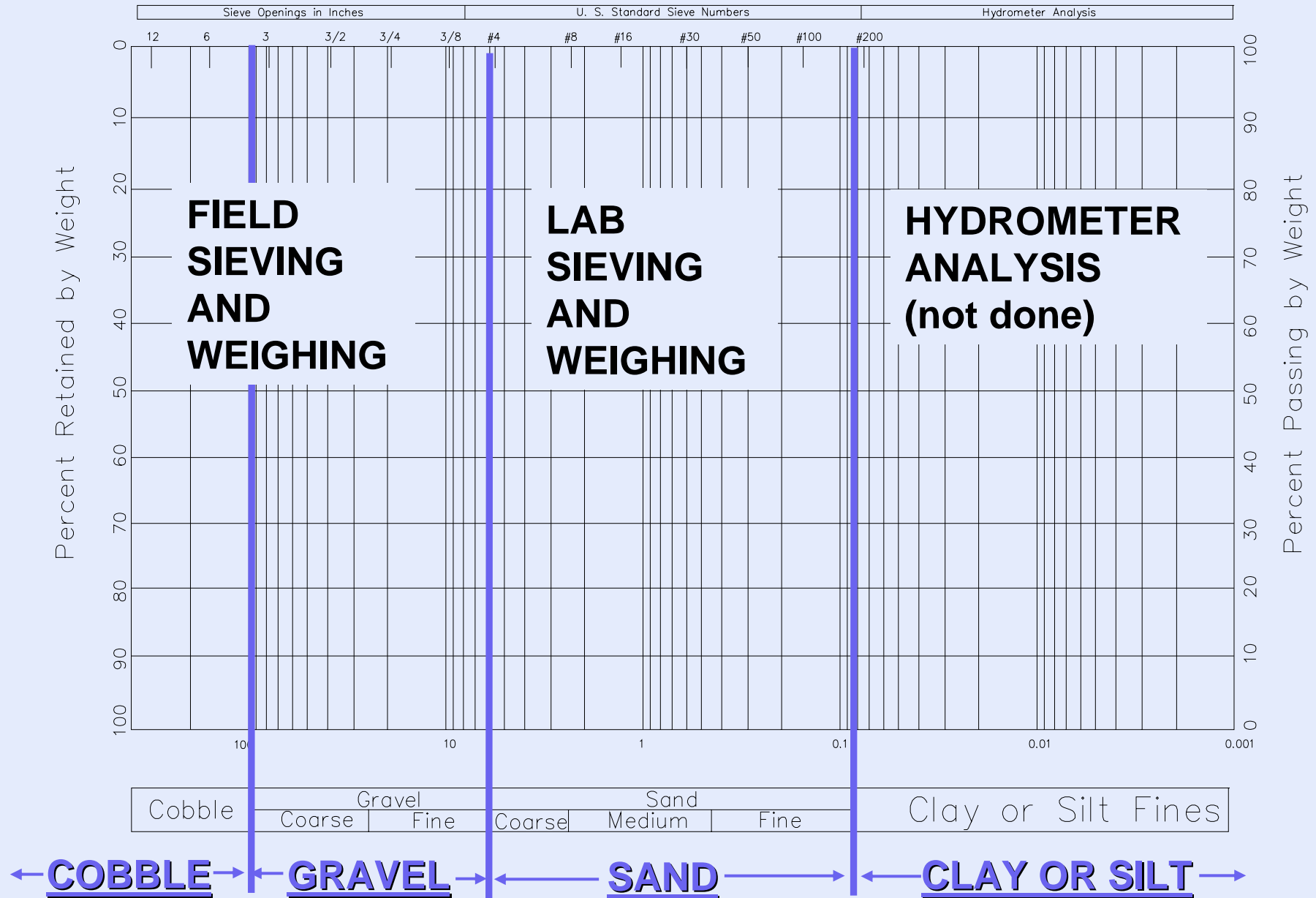


**FIELD**



**OFFICE**

# Cumulative Grain Size Curve

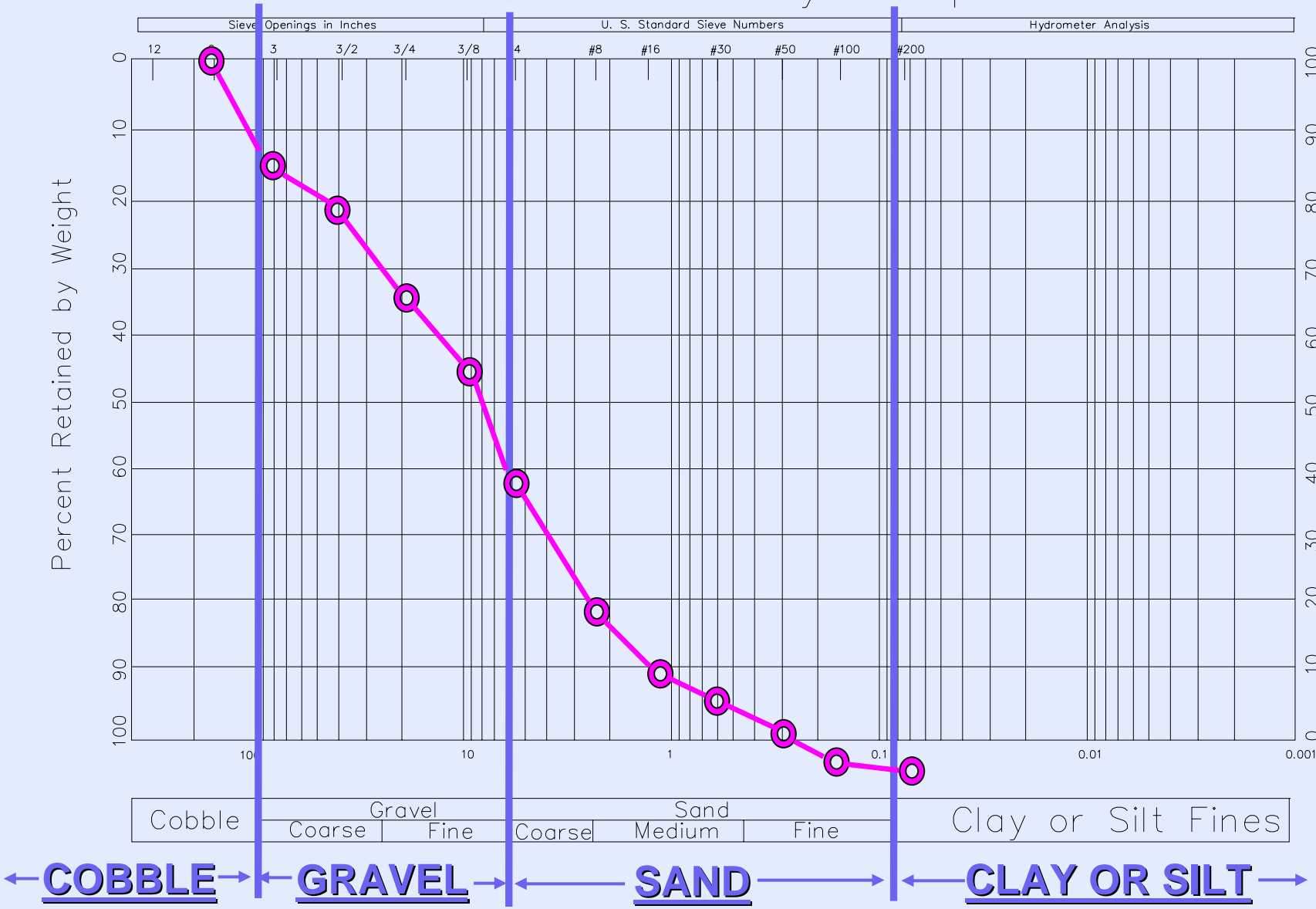


# Plot Data Points (cumulative %)

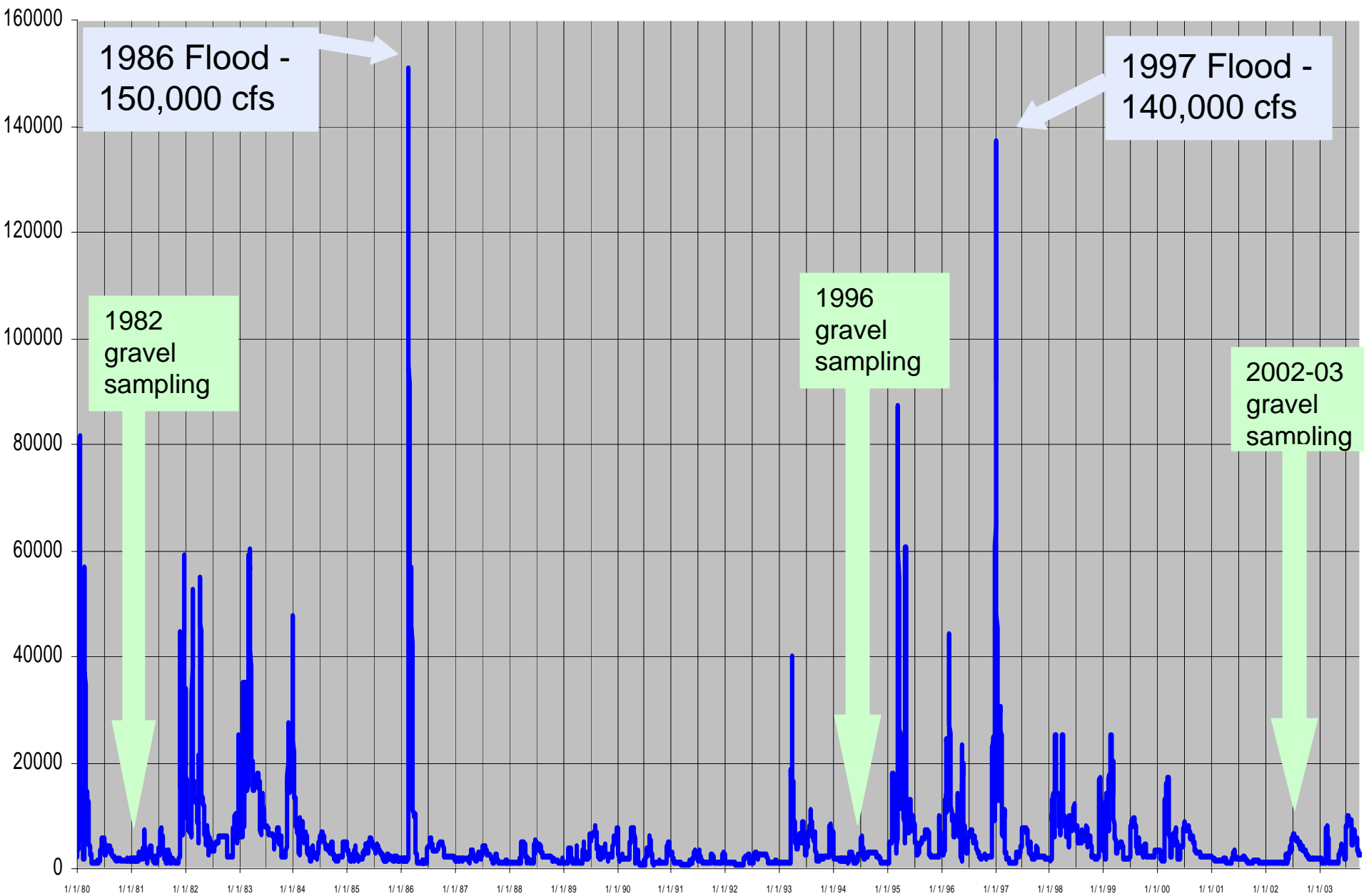
THE RESOURCES AGENCY  
DEPARTMENT OF WATER RESOURCES

NORTHERN DISTRICT  
GEOLOGY SECTION

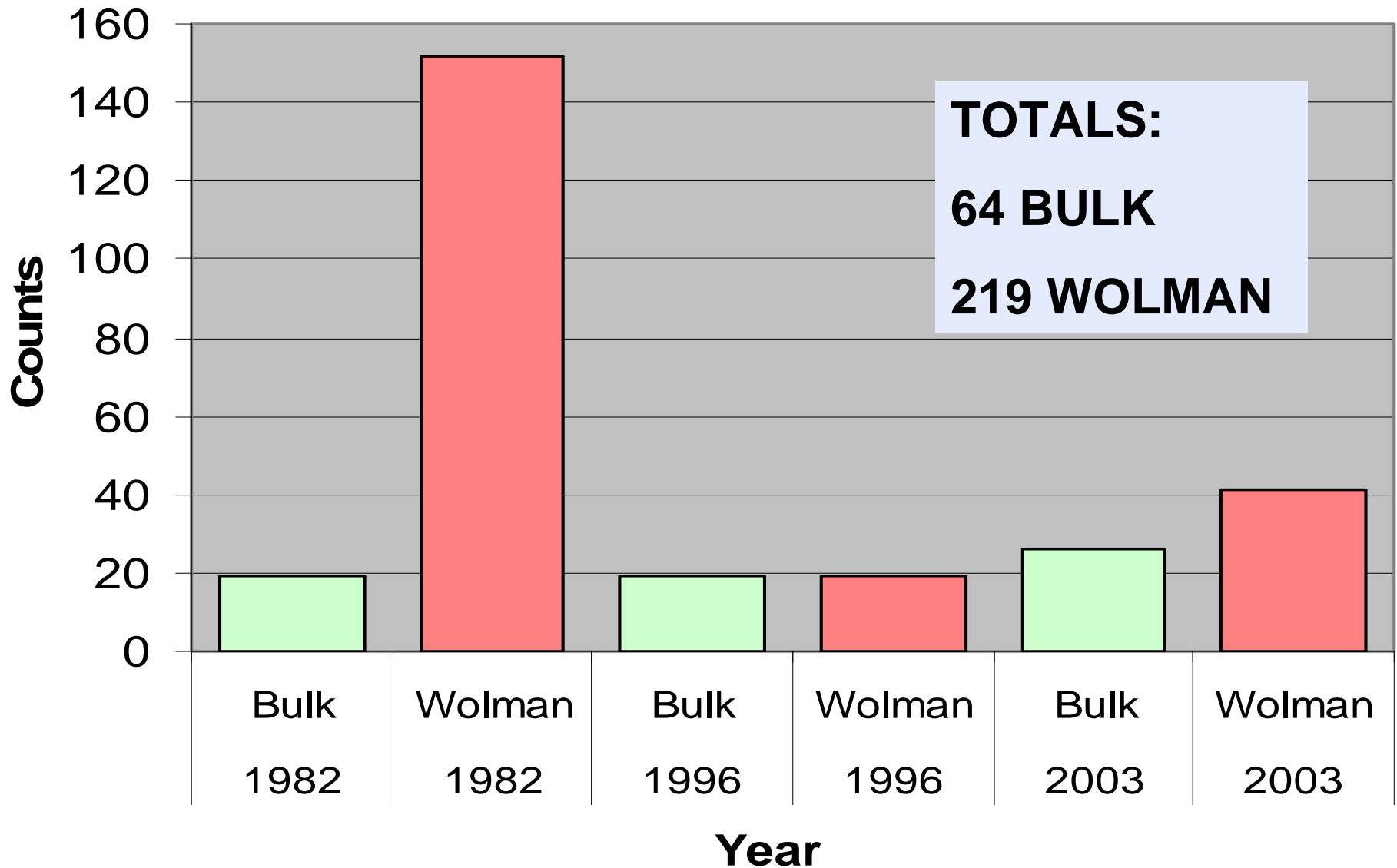
Mechanical Analysis Graph



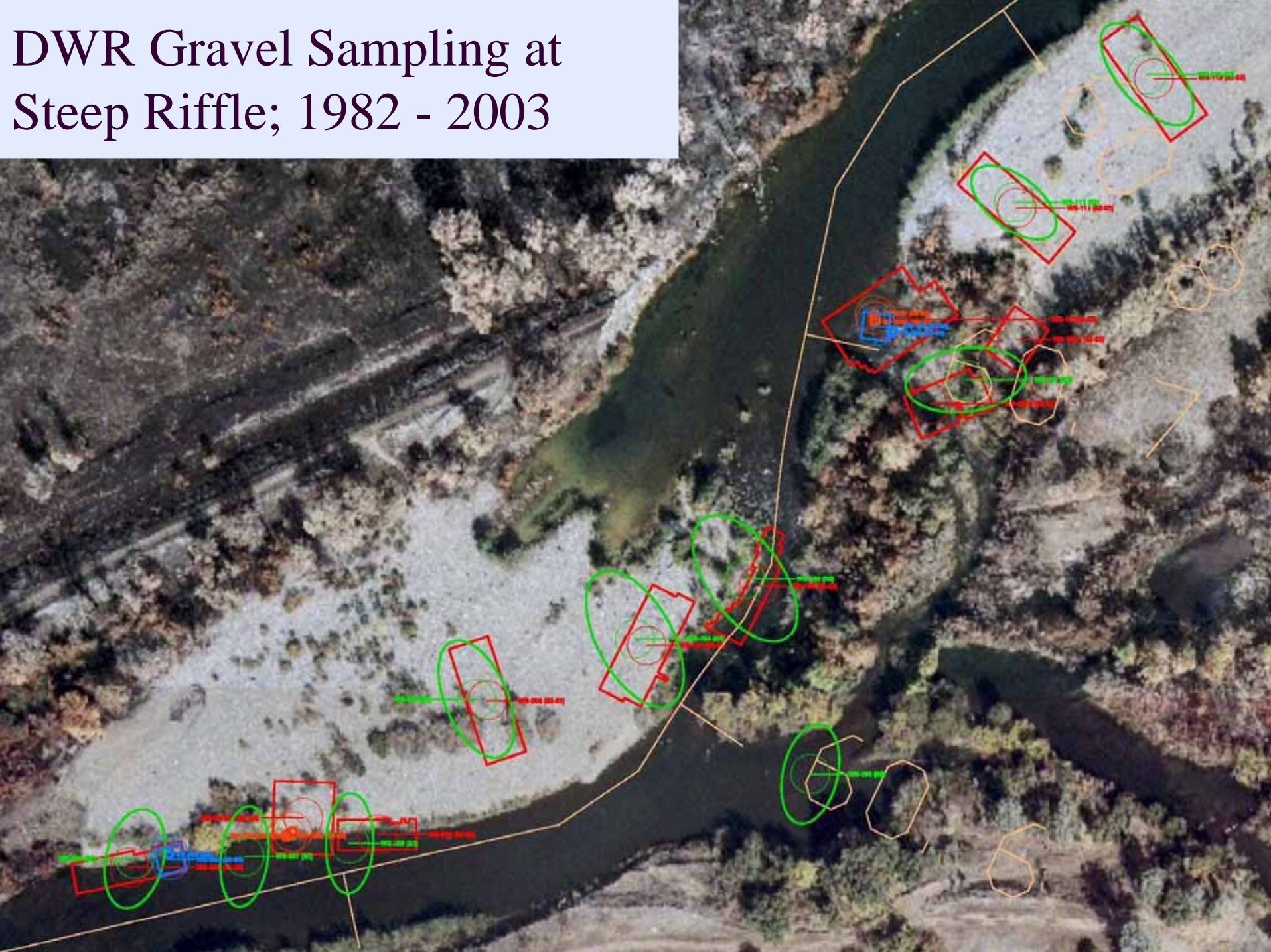
# to Honcut Creek (High Flow), 1982 - 2003



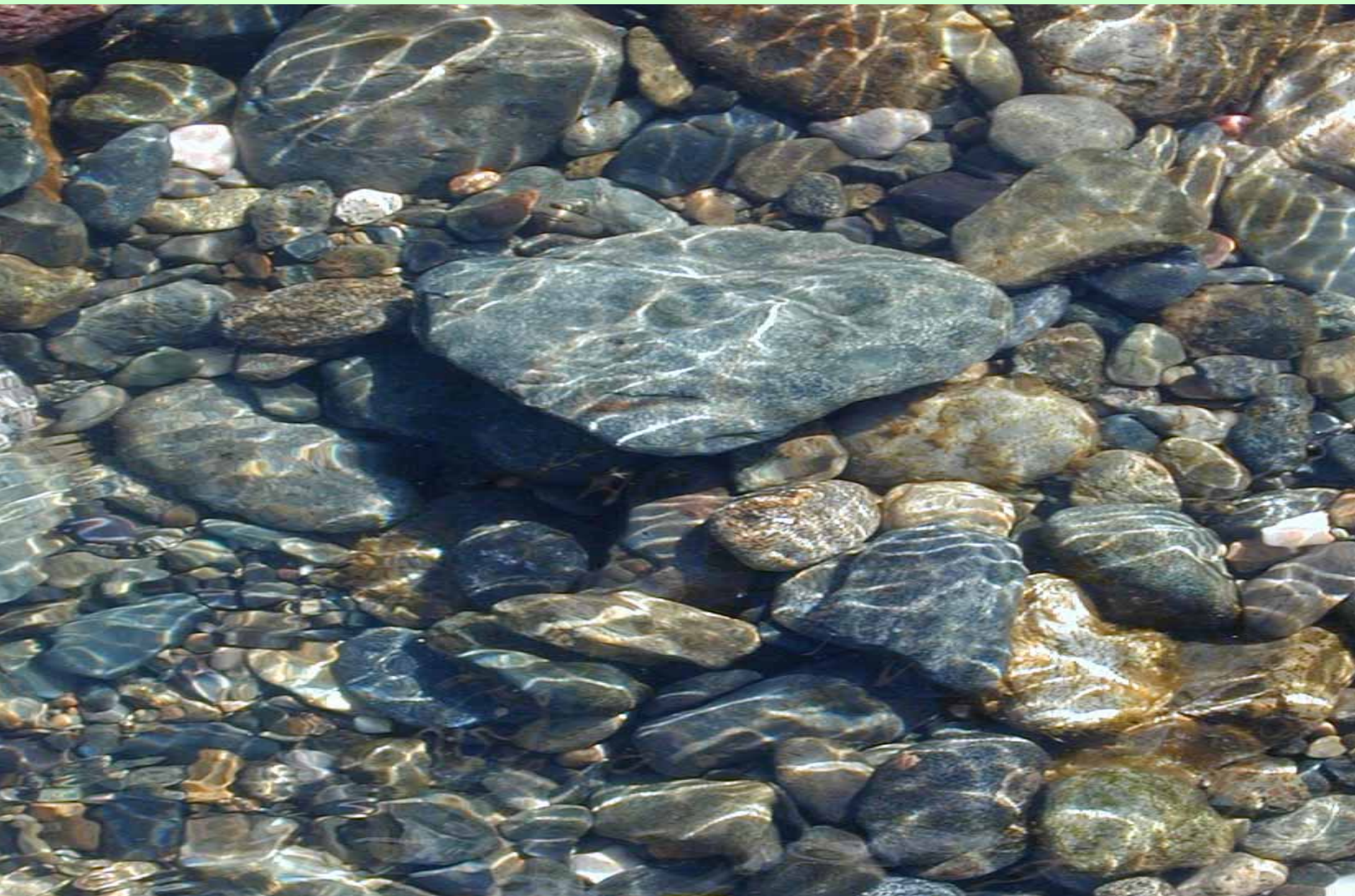
# DWR Bulk and Wolman Sampling, FDD to Honcut Creek (1982 - 2003)



# DWR Gravel Sampling at Steep Riffle; 1982 - 2003



# GRAVEL SAMPLE ANALYSIS

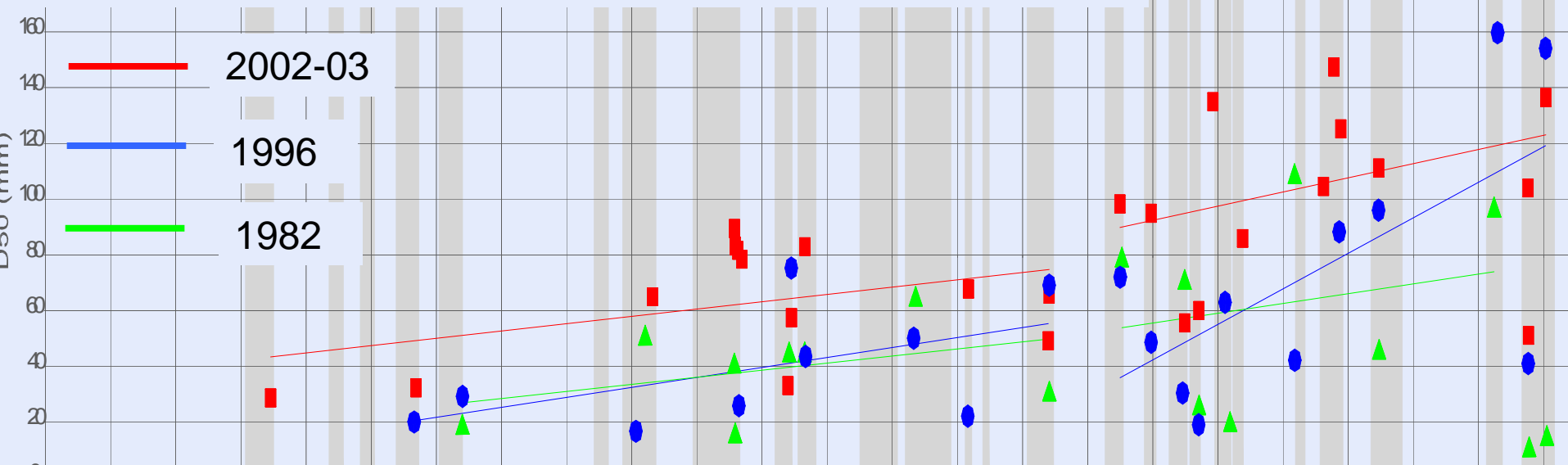


River Mile (USACE)	Riffle/Feature	Office Code (CURRENT)	D5 (mm)	D16 (mm)	D25 (mm)	D50 (mm)	D75 (mm)	D84 (mm)	D95 (mm)	Dg (mm)	Armoring Ratio (D50/D50 <sub>a</sub> )	Armoring Ratio (Dg/Dg <sub>a</sub> )	Sigma - (root of percentile method) (mm)	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (mm)	Description of Kurtosis --- Frequency (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
BULK SAMPLE																	
71.50	Thermalito																
67.13	Thermalito																
66.54	Fish																
66.28	Tail																
66.03																	
66.03																	
66.03																	
65.77	Moes' Ditch	BS-bb002-82-2002A	5	19	28	57	102	122	143	48	3.03	3.25	2.54	51.63	very negative	normal	moderate
65.77	Moes' Ditch	BS-bb002-82-2002B	1	3	6	19	48	63	99	15			4.27	29.79	negative	normal	very poor
65.77	Moes' Ditch	BS-bb002-82-2002C	2	7	13	35	71	97	136	25			3.81	45.13	very negative	normal	poor
65.76	Auditor															peaked	moderate
65.76	Auditor															normal	very poor
65.76	Auditor															normal	very poor
65.76	Auditor															normal	poor
65.76	Auditor															normal	very poor
65.76	Auditor															peaked	very poor
65.76	Auditor															peaked	poor
65.76	Auditor															peaked	poor
65.76	Auditor															highly peaked	moderate
65.23	Bedrock															normal	very poor
65.23	Bedrock															normal	very poor
65.23	Bedrock															normal	very poor
65.00	HIGHWAY																
64.27	River Run															normal	moderate
63.87	HIGHWAY																
63.47	Mathey															normal	moderate
63.47	Mathey															t	very poor
63.47	Mathey															peaked	poor
62.89	Aleck															t	poor
62.89	Aleck															normal	very poor
62.89	Aleck															peaked	very poor
62.78	Aleck															normal	moderate
62.78	Aleck															normal	very poor
62.78	Aleck															normal	very poor
62.62	Aleck															peaked	poor
62.62	Aleck															t	very poor
62.62	Aleck															normal	very poor
61.38	Robinson F															peaked	poor
61.38	Robinson F															normal	poor
61.38	Robinson F															normal	poor
61.14	Robinson F															highly peaked	moderate
61.14	Robinson F															t	very poor
61.14	Robinson F															normal	very poor
61.14	Robinson F															peaked	poor
61.14	Robinson F															normal	very poor
61.14	Robinson F															normal	very poor
61.14	Robinson F															peaked	poor
61.14	Robinson F															normal	very poor
61.14	Robinson F															peaked	very poor
60.71	Steep															peaked	poor
60.71	Steep															peaked	poor
60.71	Steep															normal	poor
60.71	Steep															peaked	poor
60.71	Steep															peaked	poor
60.71	Steep															peaked	poor
60.71	Steep															peaked	moderate
60.71	Steep															peaked	poor
60.71	Steep															highly peaked	poor
60.49	Weir															peaked	poor
60.49	Weir															peaked	very poor
60.49	Weir															peaked	poor
60.49	Weir															normal	poor
60.49	Weir															normal	very poor
60.49	Weir															peaked	poor
60.49	Weir															peaked	poor
60.49	Weir															t	very poor
60.49	Weir															peaked	poor
59.97	Eye															t	very poor
59.97	Eye															peaked	poor
59.97	Eye															peaked	very poor
59.49	Gateway															normal	moderate
59.49	Gateway Riffle	BS-rt010-96-2003B	1	4	13	47	85	114	145	23			5.04	54.63	very negative	normal	very poor
59.49	Gateway Riffle	BS-rt010-96-2003C	2	18	34	73	128	145	178	51			2.86	63.64	very negative	highly peaked	poor
58.72	THERMALITO SPILLWAY																

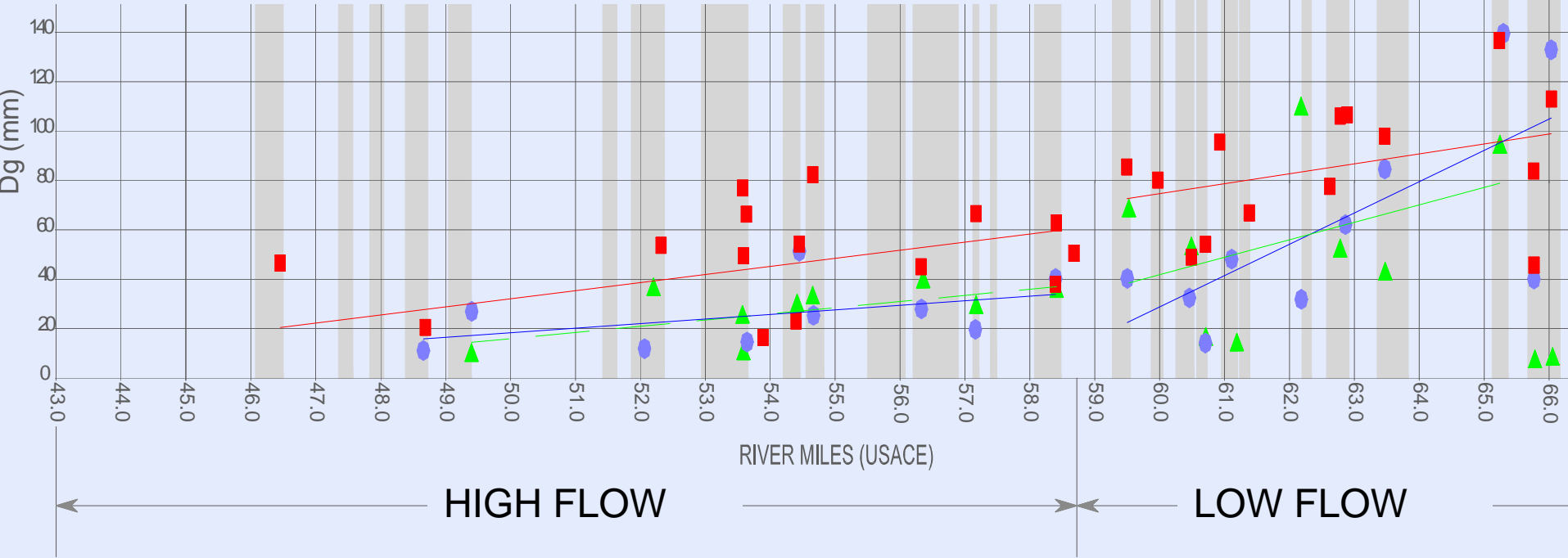
# GRAVEL SAMPLE STATISTICS

- calculated standard descriptive statistics = mean (D50), standard deviation, skewness, kurtosis and sorting
- also geometric mean (Dg) = (D16\*D84)<sup>0.5</sup>
- most useful = D50 and Dg
- D50 (mean) more understandable
- Dg more usable for gravel quality analysis

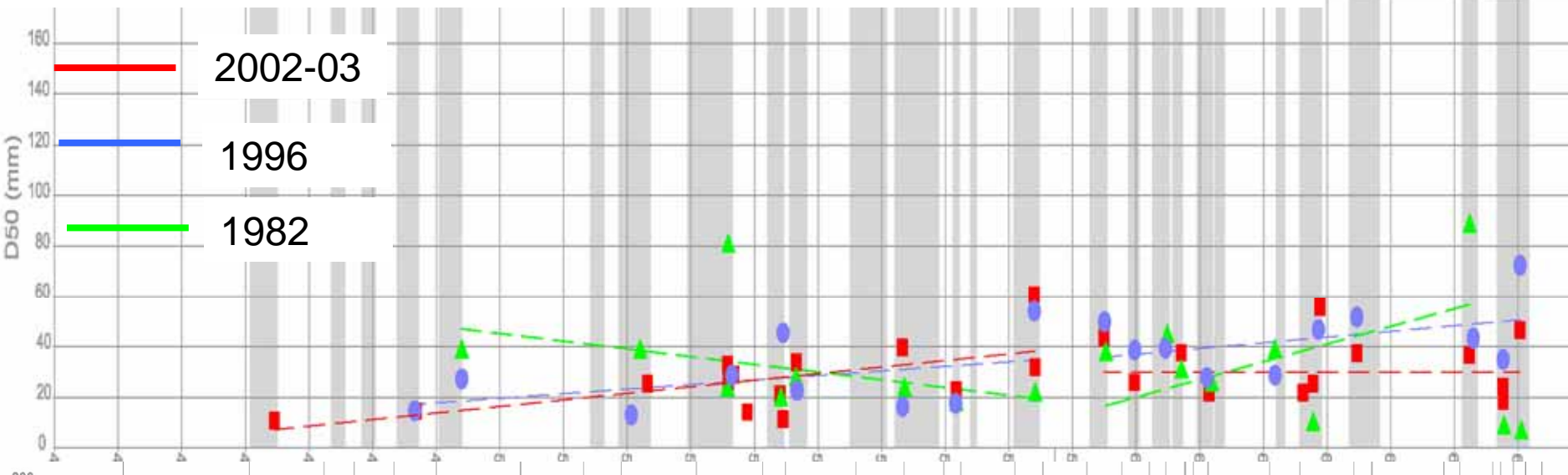
**Bulk Surface D50 by River Mile (1982-2003)**



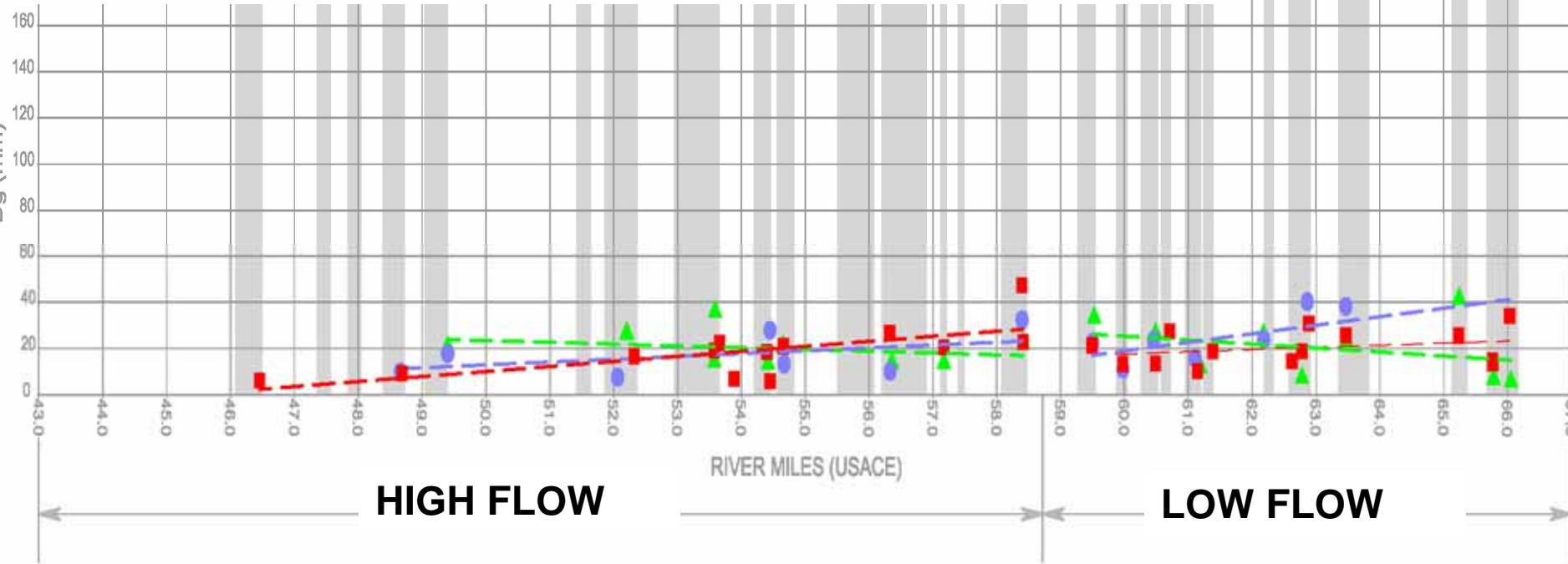
**Bulk Surface Dg by River Mile (1982-2003)**



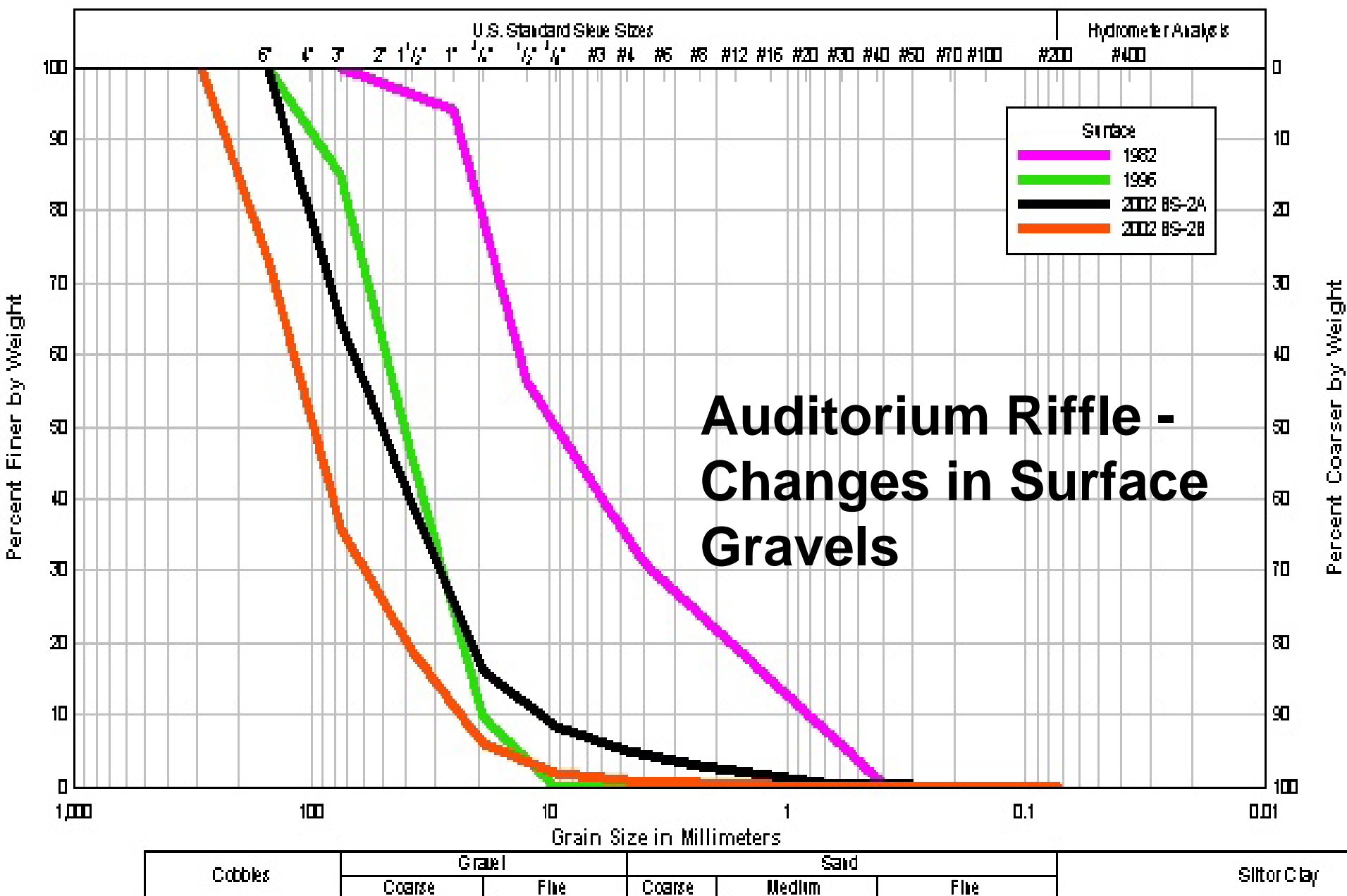
**Bulk Subsurface D50 by River Mile (1982-2003)**



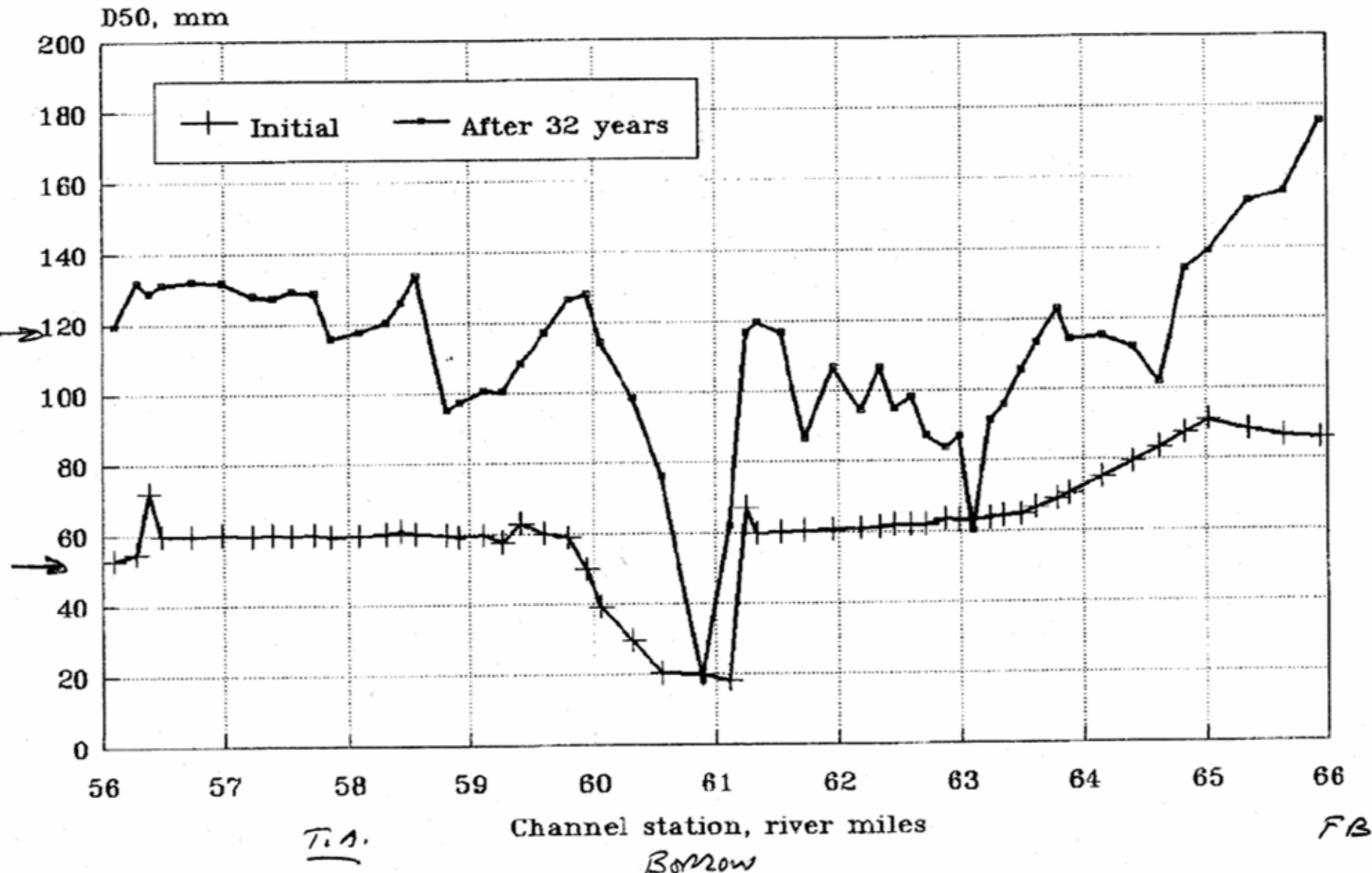
**Bulk Subsurface Dg by River Mile (1982-2003)**



## BS-2 (Surface) 1982; 1996; 2002



# TASK 7 – Predicted Changes in D50 Gravel Diameter



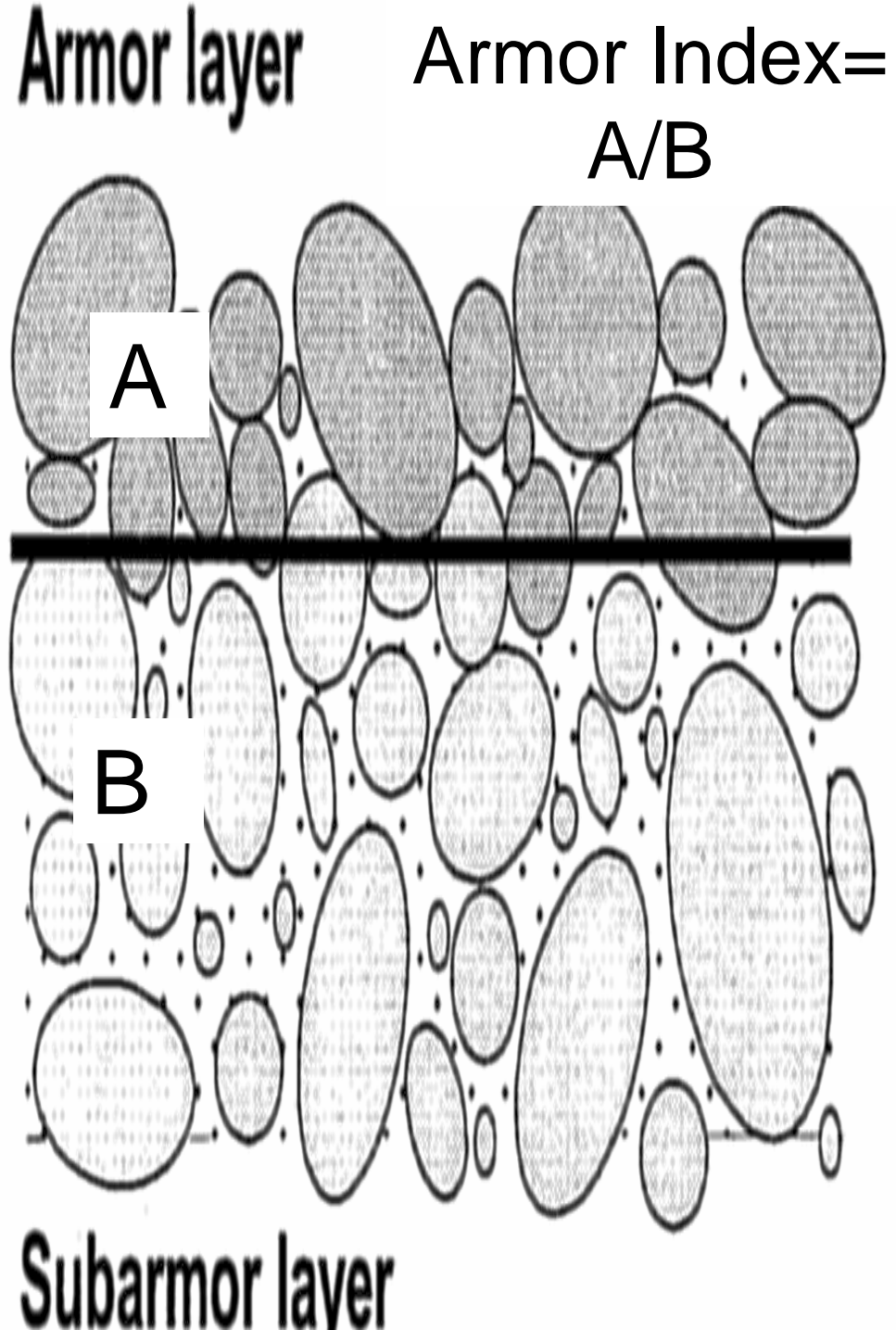


# SPAWNING RIFFLE CHARACTERIZATION



**“ARE THE GRAVELS ARMORED?”**

# GRAVEL ARMORING



# SOME CAUSES OF GRAVEL ARMORING



GRAVEL MINING – creates hydraulic “drop” that increases channel gradient



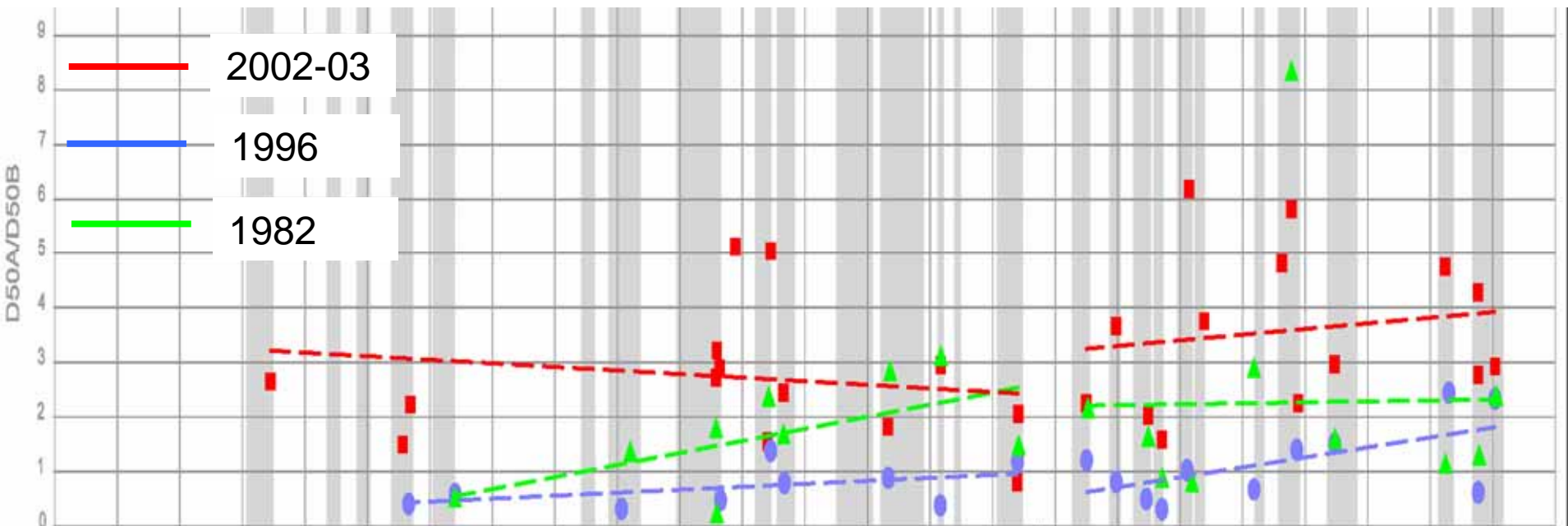
LEVEES – restriction of floodway concentrates flow



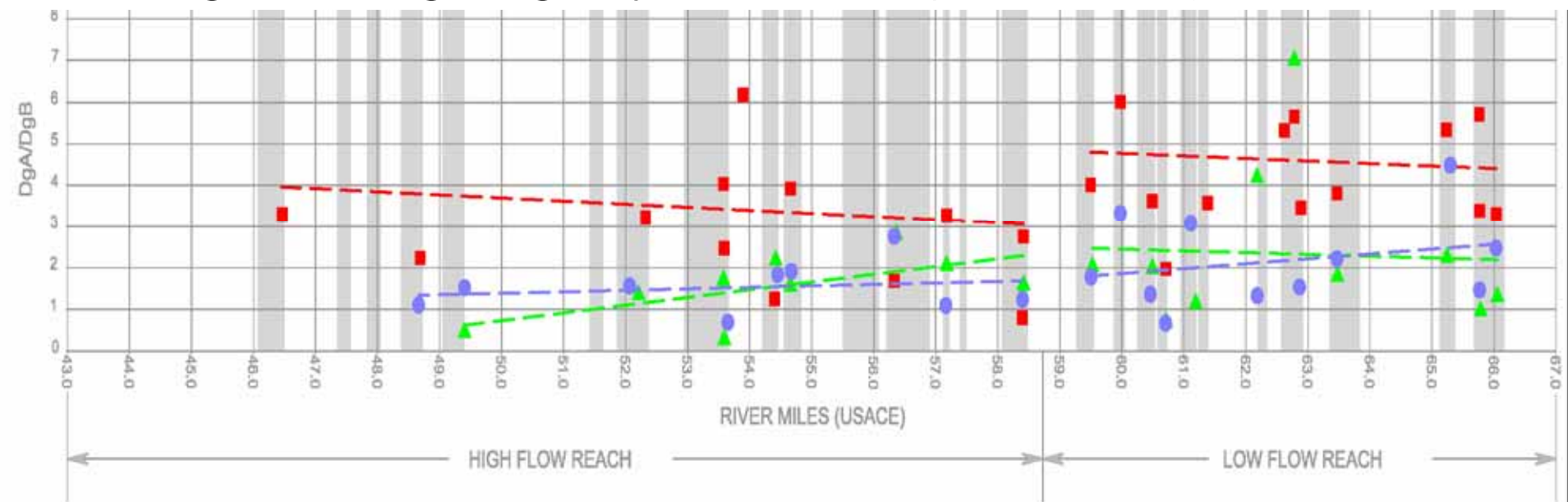
OROVILLE DAM – blocks recruitment of fresh gravel while releases continue to transport gravel; also moderates flood events



# Armoring Ratio D50a/D50b by River Mile (1982-2003)



# Armoring Ratio Dga/Dgb by River Mile (1982-2003)



# RIVER ARMORING

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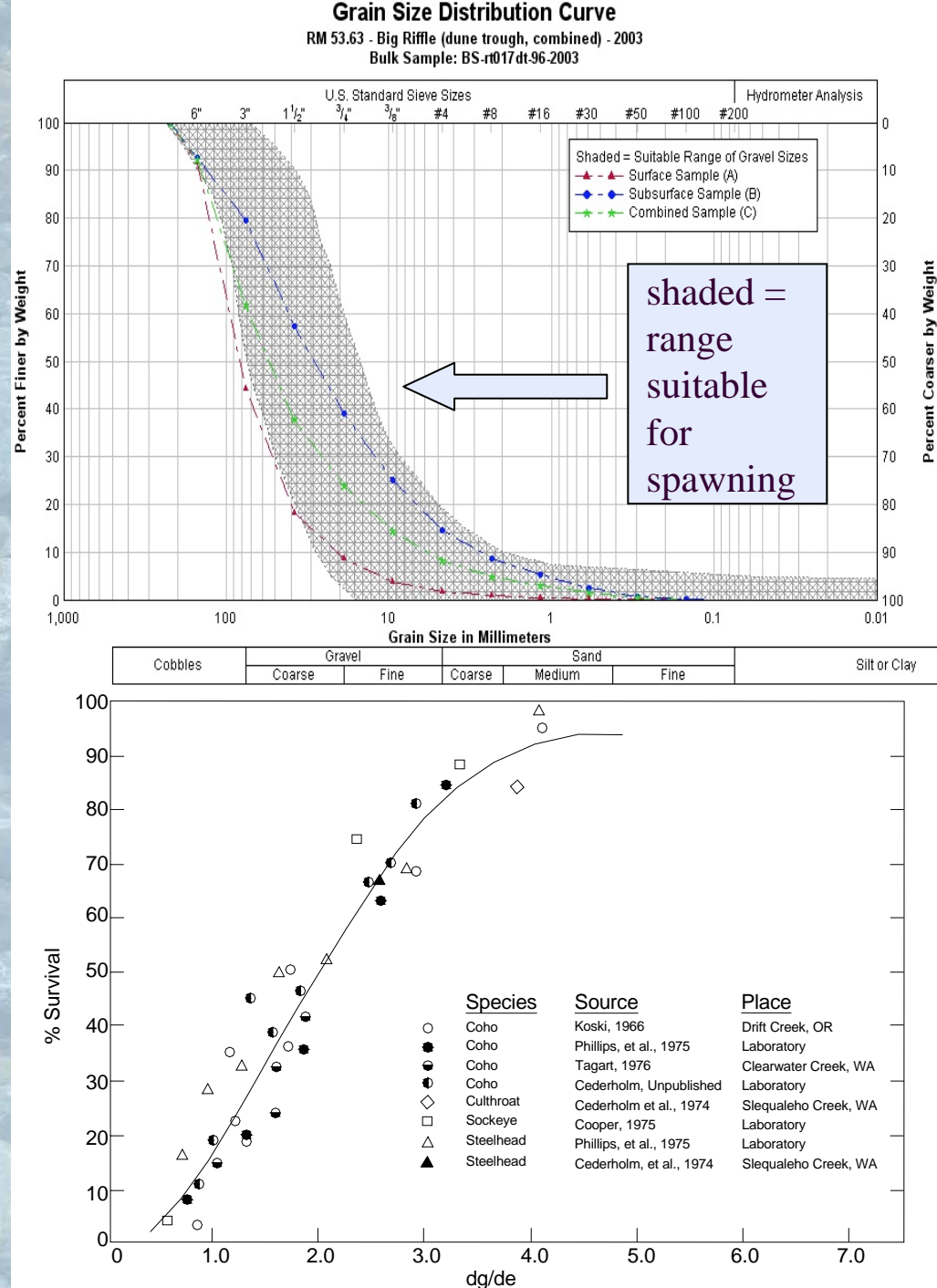
- Gravel bed sampling in 1982, 1996, and 2002-03 indicates that armoring is becoming more severe with time
- Bed armoring extends down to Honcut Creek
- Parts of the Low Flow reach armored with cobbles and boulders too coarse for salmon to move --- salmon forced to spawn in less than ideal conditions

# SPAWNING RIFFLE CHARACTERIZATION

**“WHAT IS THE QUALITY OF SPAWNING GRAVELS?”  
(compare gravel sample statistics with optimal  
ranges for spawning)**

# SPAWNING GRAVEL QUALITY CRITERIA

- variety of approaches
- all set limits on % of “fines” acceptable
- upper limits on % of coarse gravels less clear
- also dependent on life stage, i.e. redd construction, incubation, and emergence



# ASSESSING SALMONID SPAWNING GRAVEL QUALITY

LIFE STAGE  
FUNCTION:

DIGGING REDD

INCUBATION

EMERGENCE

PHYSICAL  
MECHANISM

REQUIREMENTS

CONTROLLING  
FACTORS

Fish must  
move gravel

Gravel small enough  
for fish to move

Balance between gravel  
supply transport

Gravel yield from  
watershed

Removal of  
metabolic wastes

Dissolved  
oxygen to eggs

Redds must  
remain under  
water

Egg pockets must  
remain stable

Fry must migrate  
to surface

Adequate intragravel flow  
 $v = -K(dh/dl)$   
which depends upon:

Sufficient  
hydraulic  
gradient

Sufficient  
permeability

Redds must not  
dry up or freeze

No scour of egg  
pocket during  
incubation

Open pores in  
gravel

Position in  
longitudinal  
profile

Flow

Amount of fine sediment  
( $<1$  mm) in gravel,  
affected by:  
-cleaning during spawning  
-fine sediment infiltration  
after spawning

Water level  
and  
temperature

Vertical location  
of redds

Seasonal timing  
of incubation

Upwelling  
currents

Location with  
respect to scour

Size of  
framework  
gravels

Seasonal timing  
of incubation

Amount of fine  
(1-10 mm)  
sediment in  
gravel

Below dams, may  
add gravel

In channelized  
reaches, gravels  
may wash out  
from high shear  
stress

Undulating bed  
profile promotes  
intragravel flow

Need flows to  
maintain hydraulic  
gradient

Suspended sediment  
after spawning may  
infiltrate into gravel,  
reducing incubation  
success

Maintain flows during  
incubation to prevent  
desiccation or  
freezing

Avoid high  
releases during  
incubation

Suspended sediment  
after spawning may  
infiltrate into gravel,  
reducing spawning  
success

MANAGEMENT  
IMPLICATIONS

River Mile (USACE)	Riffle/Feature	Office Code (CURRENT)	Warner--- % of sample 6 to 12 inches (152.4 to 304.8 mm)	Warner--- % of sample 3 to 6 inches (76.2 to 152.4 mm)	Warner--- % of sample 1 to 3 inches (25.4 to 76.2 mm)	Warner--- % of sample 0.5 to 1 inches (12.7 to 25.4 mm)	Warner--- % of sample 0.16 to 0.5 inches (4.06 to 12.7 mm)	Warner--- % of sample 0.015 to 0.16 inches (0.38 to 4.06 mm)	Warner--- % of sample less than 1.0 inches (0.0 to 25.4 mm)	Shirazi--- Chinook embryo survivability (%) (based on Dgr/De; De= 7.1 mm)	Tappel and Bjornn--- embryo survivability curves (% passing 9.5 mm vs % passing 0.85 mm)	Bjornn--- McCudden--- Chinook embryo survivability (%)	Hall and Lantz--- % 1-3 mm	OVERALL QUALITY RATING (qualitative based on overview of ratings)
			<= 30 %	>= 40 %	< 50 %	<= 20 %	<= 20 %	<= 20 %	<= 20 %	70 - 100 %	70 - 100 %	70 - 100 %	< 10 % and > 20 %	GOOD
			30-40%	20-40%	50-80%	20-25%	20-25%	20-25%	20-40%	50 - 70 %	50 - 70 %	50 - 70 %		FAIR
			>= 40 %	<= 20 %	>= 80 %	>= 25 %	>= 25 %	>= 25 %	>= 40 %	0 - 50 %	0 - 50 %	0 - 50 %	10 - 20 %	POOR
66.03	Hatchery Riffle	BS-rt001-96-2003A	45	33	21	1	1	0	2	n/a	95	91	0.1	FAIR
66.03	Hatchery Riffle	BS-rt001-96-2003B	13	21	34	12	11	8	32	95	95	81	4.8	FAIR
66.03	Hatchery Riffle	BS-rt001-96-2003C	29	27	27	7	6	4	17	n/a	95	91	2.4	FAIR
65.77	Moes' Ditch	BS-bb002-82-2002A	0	36	43	11	6	4	22	n/a	95	91	2.6	FAIR
65.77	Moes' Ditch	BS-bb002-82-2002B	0	7	37	17	21	18	56	54	87	33	10.9	POOR
65.77	Moes' Ditch	BS-bb002-82-2002C	0	21	39	15	13	11	39	88	93	74	6.7	FAIR
65.76	Auditorium Riffle	BS-rt002t-96-2002A	63	28	5	2	1	1	4	n/a	95	91	0.5	POOR
65.76	Auditorium Riffle	BS-rt002t-96-2002B	0	8	39	17	14	21	53	41	84	38	12.9	POOR
65.76	Auditorium Riffle	BS-rt002t-96-2002C	31	18	22	9	8	11	29	n/a	95	81	6.7	FAIR
65.76	Auditorium Riffle	BS-rt002dt-96-2002A	31	34	27	6	2	1	8	n/a	95	91	0.4	GOOD
65.76	Auditorium Riffle	BS-rt002dt-96-2002B	3	9	40	17	14	16	49	57	90	53	10.1	POOR
65.76	Auditorium Riffle	BS-rt002dt-96-2002C	17	21	33	12	8	9	29	n/a	95	85	5.3	FAIR
65.76	Auditorium Riffle	BS-rt002d-96-2002A	0	39	48	10	2	0	13	n/a	95	91	0.3	GOOD
65.76	Auditorium Riffle	BS-rt002d-96-2002B	6	10	41	17	14	12	44	80	93	71	7.4	POOR
65.76	Auditorium Riffle	BS-rt002d-96-2002C	3	24	44	14	8	6	29	95	95	88	3.8	FAIR
65.23	Bedrock Park Riffle	BS-gm003-82-2003A	68	18	9	2	2	1	5	n/a	95	91	1.0	POOR
65.23	Bedrock Park Riffle	BS-gm003-82-2003B	10	18	32	14	12	13	39	90	93	72	7.9	FAIR
65.23	Bedrock Park Riffle	BS-gm003-82-2003C	39	18	21	8	7	7	22	n/a	95	87	4.4	FAIR
65.00	HIGHWAY 70 BRIDGE													
64.27	River Run Park Pool	BS-pb001-xx-2003A	0	28	59	9	3	0	13	n/a	95	91	0.2	GOOD
63.87	HIGHWAY 162 BRIDGE													
63.47	Mathews Riffle	BS-rt004-96-2002A	29	45	21	3	1	0	5	n/a	95	91	0.2	GOOD
63.47	Mathews Riffle	BS-rt004-96-2002B	10	25	25	13	14	12	40	90	92	65	7.0	POOR
63.47	Mathews Riffle	BS-rt004-96-2002C	19	35	23	8	8	6	22	n/a	95	87	3.6	FAIR
62.89	Aleck Riffle	BS-rt005-96-2003A	23	22	26	4	3	1	8	n/a	95	91	0.7	FAIR
62.89	Aleck Riffle	BS-rt005-96-2003B	18	22	30	8	10	12	31	94	94	76	7.8	FAIR
62.89	Aleck Riffle	BS-rt005-96-2003C	17	22	28	6	6	7	19	n/a	95	88	4.3	FAIR
62.78	Aleck Riffle	BS-gt005-82-2003A	49	27	19	3	2	0	5	n/a	95	91	0.3	FAIR
62.78	Aleck Riffle	BS-gt005-82-2003B	8	11	33	15	17	15	48	75	90	47	8.6	POOR
62.78	Aleck Riffle	BS-gt005-82-2003C	28	19	26	9	9	8	27	n/a	95	84	4.4	FAIR
62.62	Aleck Tailings	BS-TP-bm009-xx-2003A	29	38	20	5	3	4	13	n/a	95	91	2.0	GOOD
62.62	Aleck Tailings	BS-TP-bm009-xx-2003B	11	15	23	12	15	21	52	57	73	26	11.7	POOR
62.62	Aleck Tailings	BS-TP-bm009-xx-2003C	20	26	21	8	9	12	32	93	92	73	6.8	FAIR
61.38	Robinson Riffle (upper)	BS-rt006-xx-2003A	10	48	31	6	4	1	11	n/a	95	91	0.5	GOOD
61.38	Robinson Riffle (upper)	BS-rt006-xx-2003B	4	8	38	18	21	12	51	75	92	51	6.9	POOR
61.38	Robinson Riffle (upper)	BS-rt006-xx-2003C	7	28	34	12	12	6	31	95	95	83	3.7	FAIR
61.14	Robinson Riffle (lower)	BS-bt007d-xx-2003A	72	19	5	1	2	1	5	n/a	95	91	0.8	POOR
61.14	Robinson Riffle (lower)	BS-bt007d-xx-2003B	4	17	28	12	14	20	51	38	67	29	9.3	POOR
61.14	Robinson Riffle (lower)	BS-bt007d-xx-2003C	38	18	16	7	8	11	28	95	93	78	5.0	FAIR
61.14	Robinson Riffle (lower)	BS-bt007dt-xx-2003A	45	27	17	4	4	3	11	n/a	95	91	1.8	FAIR
61.14	Robinson Riffle (lower)	BS-bt007dt-xx-2003B	4	13	31	13	14	20	52	35	69	31	9.2	POOR
61.14	Robinson Riffle (lower)	BS-bt007dt-xx-2003C	25	20	24	9	9	12	31	94	92	76	5.5	FAIR
GRAVEL QUALITY RATINGS											95	90	2.8	GOOD
											71	33	9.2	POOR
											92	72	6.0	FAIR
											95	91	0.8	GOOD
											95	85	4.0	FAIR
											95	91	2.4	FAIR

# Gravel Quality Ratings

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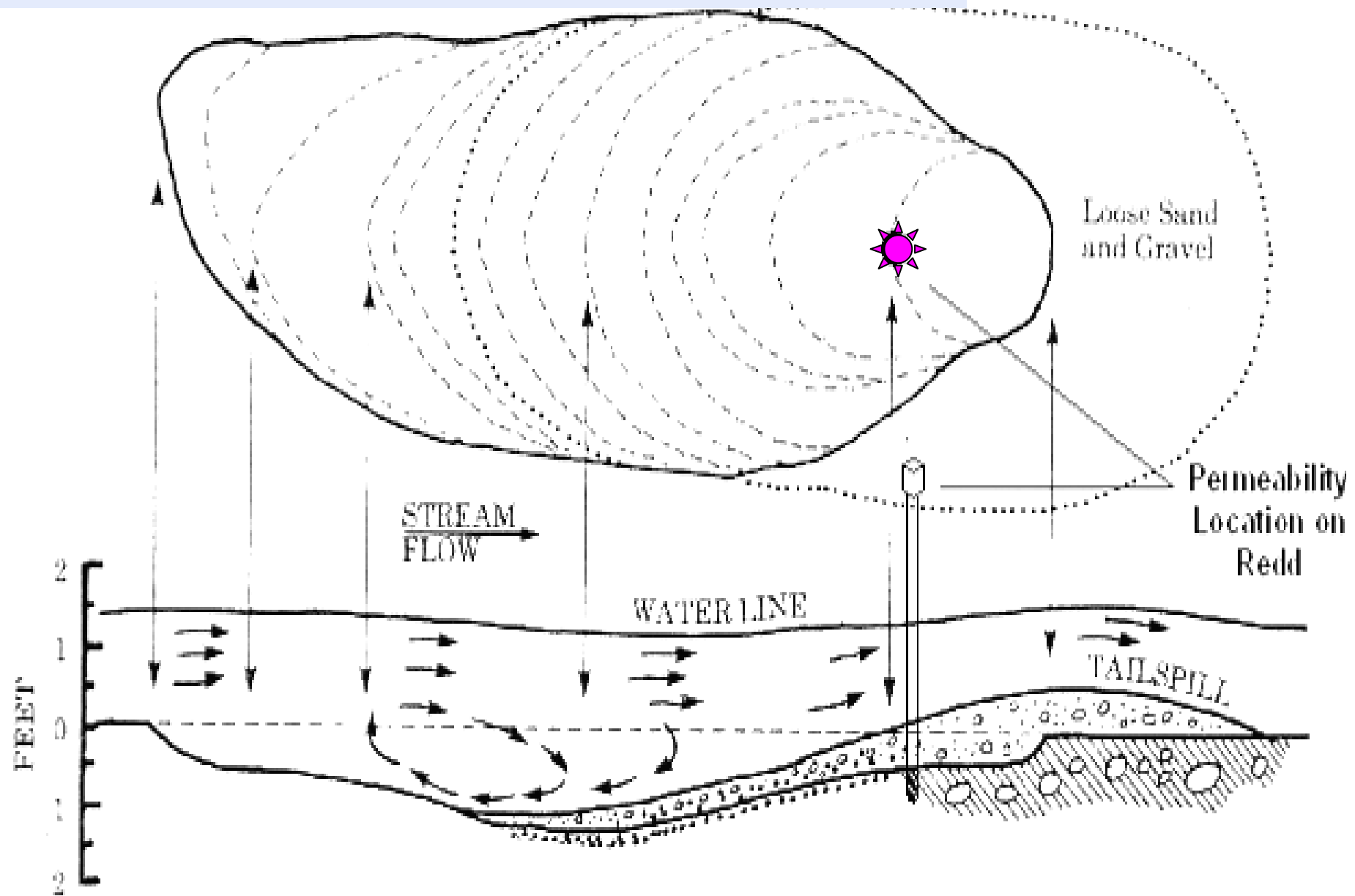
- Fine gravel data suggest that, on the average, samples meet fine spawning gravel quality criteria
- Also the spawning process probably removes some of the fines
- Coarse gravel data indicates that many of the samples are coarser than optimal for salmon to move especially in the Low Flow reach

# SPAWNING RIFFLE CHARACTERIZATION

**“IN GENERAL WHAT ARE THE PERMEABILITIES,  
TEMPERATURES, DISSOLVED OXYGEN LEVELS,  
AND VELOCITIES AT THESE RIFFLES?”**

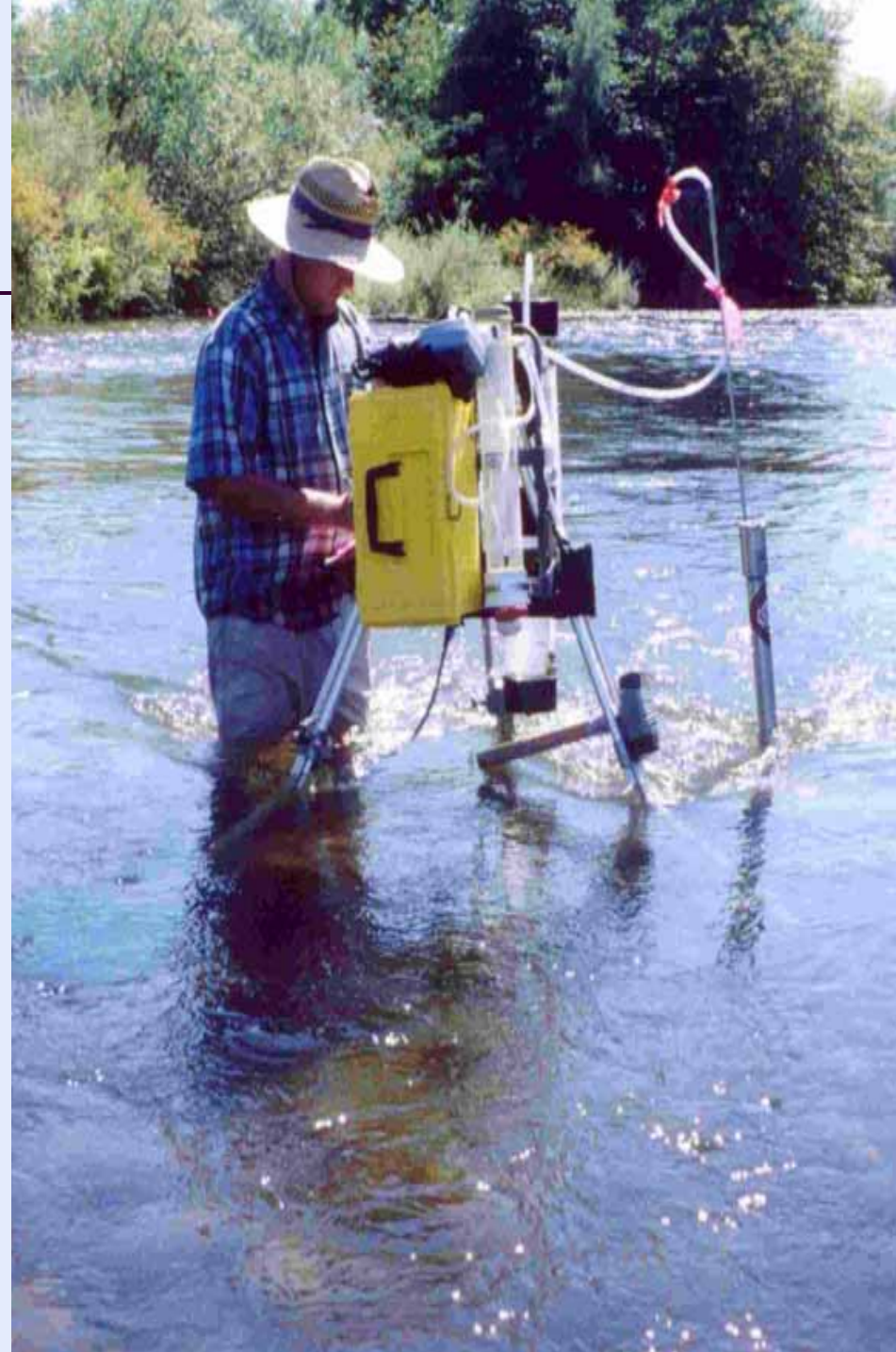
(take appropriate measurements; also try diurnal  
sampling)

# PERMEABILITY TESTING



# Permeability, Temperature and Dissolved Oxygen

- 15 riffles tested October through November 2003
- testing performed at 6", 12" and 18" depth
- also diurnal measurements performed at Auditorium Riffle



# RESULTS

- Permeabilities generally high in the top 12", significantly lower below
- River water and intragravel temperatures nearly equal (generally within 1/10 degree Celsius)
- DO generally high
- Diurnal testing showed little variation in DO or temp

Reach	Riffle	Location on Riffle	Site Code	PERMEABILITY (cm/hr)		
				6 inch	12 inch	18 inch
Feather River Low	Hatchery	Top	PT-HR-C	27,300	600	300
		Middle	PT-HR-D	38,800	5,900	600
		Bottom	PT-HR-E	7,500	700	1,100
	Auditorium	Top	PT-AuR-A	8,700	9,500	10,500
		Top	PT-AuR-D	32,000	1,500	200
		Middle	PT-AuR-B	13,600	14,100	4,000
		Bottom	PT-AuR-C	31,900	8,600	4,100
	Bedrock Park	Top	PT-BR-A	25,700	6,400	1,100
		Middle	PT-BR-B	31,700	700	300
		Bottom	PT-BR-C	6,600	500	400
	Mathews	Top	PT-MR-A	30,200	33,700	2,300
		Middle	PT-MR-B	29,000	1,600	600
		Bottom	PT-MR-C	16,000	3,000	1,200
	Aleck	Top	PT-AIR-A	12,300	1,800	4,700
		Middle	PT-AIR-B	15,600	30,200	9,300
	Robinson	Top	PT-RR-A	40,300	20,100	1,000
		Middle	PT-RR-B	28,700	37,700	5,800
		Bottom	PT-RR-C	4,700	1,400	2,600
	Steep	Top	PT-SR-A	33,900	33,800	3,400
		Middle	PT-SR-B	32,600	34,500	1,200
	Weir	Top	PT-WR-A	37,200	4,500	2,100
		Middle	PT-WR-B	38,500	27,700	1,400
	Eye	Top	PT-ER-M	36,900	32,600	1,500
		Middle	PT-ER-N	22,400	2,800	3,800
		Bottom	PT-ER-O	36,700	18,600	3,200
	Gateway	Top	PT-GR-A	37,000	36,800	11,200
		Bottom	PT-GR-B	11,000	38,900	4,600
Feather River High Flow	Sutter Butte	Top	PT-SBR-A	9,800	10,000	3,300
		Middle	PT-SBR-B	34,900	4,600	2,400
		Bottom	PT-SBR-C	37,200	15,800	1,800
	Upper House	Top	PT-UHR-A	9,900	26,500	13,300
		Middle	PT-UHR-B	11,700	12,500	400
		Bottom	PT-UHR-C	38,300	31,800	500
	Keister	Top	PT-KR-A	32,500	6,700	5,000
		Middle	PT-KR-B	32,400	2,100	1,700
		Bottom	PT-KR-C	10,200	2,000	100
	Goose	Top	PT-GoR-A	21,900	35,300	1,300
	MacFarland	Top	PT-McR-A	17,900	3,000	1,300
		Bottom	PT-McR-B	26,300	35,000	22,400

Shaded areas indicate likely disturbed gravels within redd

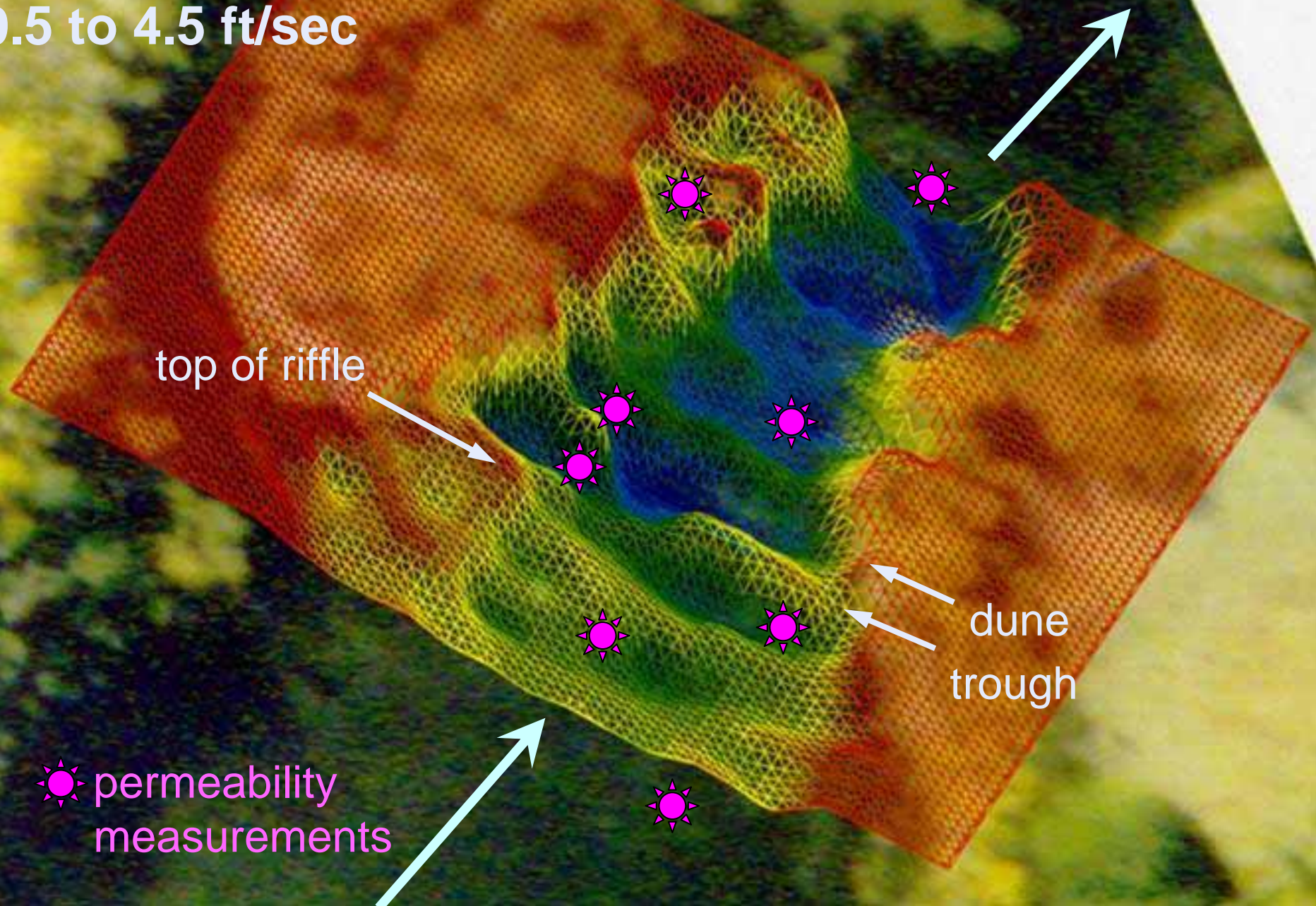
# VELOCITY MEASUREMENTS

- Point values taken during permeability testing
- Also detailed measurements taken during Wolman grid sampling at Hatchery, Eye, and Steep Riffles



# Eye Riffle Velocities 08/06/03

0.5 to 4.5 ft/sec





# SPAWNING RIFFLE CHARACTERIZATION



GRAVEL DATA USES

# GRAVEL DATA USES

- Estimate size of surface and subsurface gravels at specific riffles --- useful for ripping and raking strategies for habitat improvement
- Quantify size of dredging tailings for possible use in gravel augmentation





# SPAWNING RIFFLE CHARACTERIZATION



THE END